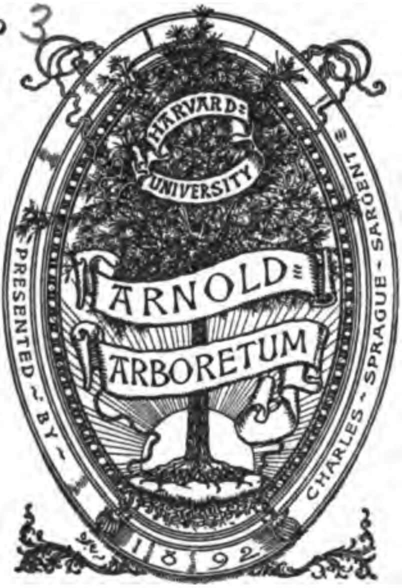
HARVARD
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ARNOLD
ARBORETUM
PRESENTED BY
CHARLES SPRAGUE SARGENT
1892

Vol. VII | No. 1

Proceedings
of
The Society of American Foresters

1912

30088

THE SOCIETY OF AMERICAN FORESTERS

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Atlantic Building, Washington, D. C.

WASHINGTON, D. C.
PRESS OF JUDD & DETWEILER, INC.
1912

CONTENTS OF VOLUME VII, No. 1

CONTENTS

WASHINGTON, D. C.

PUBLISHED BY THE SOCIETY

MARCH 1, 1912

Copies of the Proceedings may be obtained from the Secretary for 50 cents each number.

PROGRAM OF MEETINGS

1911

January 12. Open meeting. Tropical Woods as Substitutes for Northern Conifers. H. M. Curran.

February 2. Executive Meeting.

February 9. Open Meeting. The Rise of Forestry in the United States. Gifford Pinchot.

February 22. Open Meeting. Personal Recollections of a Forester. Gifford Pinchot.

March 2. Executive Meeting.

April 13. Open Meeting. What Kind of Forest Management Pays Best? T. S. Woolsey, Jr.

April 20. Open Meeting. Better Methods of Fire Control. W. B. Greeley.

November 29. Open Meeting. Some Observations on Alaska. Gifford Pinchot.

December 14. Open Meeting. The Indirect Influence of Forests in the Light of Recent Investigations. Raphael Zon.

December 28. Open Meeting. The Forestry Problem in Canada. B. E. Fernow.

PROCEEDINGS
OF
THE SOCIETY OF AMERICAN FORESTERS

The Society is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

VOL. VII 1912 No. 1

REPORT OF THE SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1911

SUMMARY

Membership Roll

Sixty-nine active and five associate members were elected during the year. The death of one active and one associate member, the resignation of two, and the dropping of five active members make the total present membership 263, divided as follows:

Active	213
Associate	49
Honorary	1
	263

The following list shows the changes in number of active members during the last three years:

Changes in Active Membership, 1909-1911, *Inclusive*

Active membership December 31, 1908	130
Elected, 1909	18
" 1910	11
" 1911	69
	228

Resigned, 1909, E. T. Allen, G. L. Clothier; 1910, Dr. Rothrock; 1911, C. G. Crawford and R. G. Wilson	5
Deceased, 1909, W. W. Clark; 1910, L. C. Miller; 1911, F. J. Phillips	3
Dropped for non-payment of dues, 1911, R. W. Ayres, R. E. Benedict, C. S. Chapman, H. B. Eastman, and Douglas Rodman	5
Declined membership, 1911	2
Active membership December 31, 1911	213
	228

The active membership of the Society is distributed geographically as follows:

District of Columbia (and Maryland)		33
Northeastern States		
Maine	2	
New Hampshire	3	
Vermont	1	
Massachusetts	8	
Connecticut	7	
New York	6	
Pennsylvania	9	
New Jersey	3	
		39
Southeastern States		
North Carolina	2	
Georgia	1	
Florida	2	
		5
Lake States		
Michigan	3	
Illinois	1	
Wisconsin	6	
Minnesota	5	
		15
Central States		
Iowa	1	
Missouri	1	
Arkansas	1	
South Dakota	2	
Nebraska	1	
Kansas	1	
Oklahoma	1	
		8

Northern Rocky Mountains		
Montana	11	
Idaho	5	
		16
Central Rocky Mountains		
Colorado	11	
Utah	5	
		16
Southwestern States		
Arizona	5	
New Mexico	11	
		16
North Coast States		
Washington	8	
Oregon	16	
		24
California and Nevada		25
U. S. Possessions		
Philippine Islands	6	
Hawaii	2	
Alaska	2	
		10
Canada		6
		213

Important Constitutional Changes

Two amendments were adopted and incorporated in the Constitution as Articles VII and VIII. Article VII provides for the affiliation with the Society of local forestry associations or clubs, two or more members of which are active members of the Society. Article VIII provides for the establishment of sections of the Society upon petition of ten or more active members. These articles were adopted by a vote of 71 to 17 and 87 to 4, respectively. Steps were taken toward the organization of a section at Missoula, and a formal petition and by-laws, signed by eleven active members, was submitted and ratified by the Executive Committee February 15, 1912.

Important Business

A committee was appointed to consider a plan of "new work," whereby the Society should undertake to formulate definite views on certain broad questions relating to forestry. The report of this committee was published in Vol. VI, No. 1, of the Proceedings.

Publication of Proceedings

During the year the Society has issued Numbers 1 and 2 of Volume 6. As compared with previous years, the Proceedings included a larger number of papers, covering a wider field. With a total of 270 pages, they also exceeded in actual size any previous volume of the Proceedings, and this in spite of the fact that, owing to a change in the paper and type, one page of the Proceedings now contains at least as much as one and one-third pages of the Proceedings of previous years.

Since relatively few of the members of the Society are now resident at Washington, special effort has been made to secure and include papers which were not delivered before the Society at its Washington meetings. In this way the Proceedings will gain a broader value and serve as a better means of unifying the Society. The Proceedings as they have appeared within the last two years, therefore, are really not Proceedings in the sense that the published papers were those which had actually been delivered at the meetings, but constitute, as they should, the official organ of the Society for expressing the ideas of its members.

A new policy introduced within the last year is the publication in the Proceedings of the annual reports of the Secretary and Treasurer and those of important special committees. By this means the members will be kept informed of the activities of the Society. Another departure is the reprinting, for sale by the Society, of certain papers which appear in the Proceedings. The bibliography on the Appalachian region which was published in Vol. VI, No. 2, was reprinted in pamphlet form, and can be bought for 25 cents a copy. The article, "Better Methods of Fire Control," by W. B. Greeley (Vol. VI, No. 2), was reprinted, and 1,500 copies were purchased by the Forest Service for distribution to Forest Rangers.

In spite of the fact that the Society has no exchange list of any kind and no announcement is made of the appearance of the Proceedings, they are becoming more and more known among people interested in forestry. There is now a mailing list of 65 regular subscribers, exclusive of the Forest Service, which purchases approximately 155 copies of each issue for its field libraries.

Deceased

During the year the Society lost by death two members, one active and one associate. Prof. F. J. Phillips died February 13, at Lincoln, Nebraska, and Prof. W. R. Dudley on June 4, in California.

E. H. Frothingham,
Secretary.

ANNUAL REPORT OF THE TREASURER

FEBRUARY 1, 1911, TO JANUARY 31, 1912

Receipts

Balance from previous Treasurer	$623.85	
Annual dues	727.00	
Sale of Proceedings	281.25	
Interest on bank deposit	15.11	
Refund of expenses of representative on Washington Academy of Science excursion to Dismal Swamp	7.50	
Refund of overcharge by Pennsylvania Railroad	.05	
		$1,654.76

Disbursements

Printing of Proceedings	$605.09	
Miscellaneous printing and stationery	129.45	
Typewriting	12.00	
Postage	41.08	
Freight and express	2.61	
Rent of Cosmos Club hall	6.00	
Flowers for F. J. Phillips' funeral	17.13	
Expenses of representative on Washington Academy of Science excursion to Dismal Swamp	7.50	
Refund of overpayment for Proceedings	1.25	
Rubber stamp for Treasurer	.30	
	$822.41	
Balance on hand	832.35	
		$1,654.76

Assets

Cash on hand	$832.35	
Dues owed for 1910	35.00	
Dues owed for 1911	63.00	
Dues owed for 1912	621.00	
Owed for Proceedings	20.00	
		$1,571.35

Liabilities

Contribution to Forest bibliography to be published by the International Association of Forest Experiment Stations.	$125.00	
Reprint of Appalachian bibliography from Vol. VI, No. 2, of the Proceedings—Judd & Detweiler.................	50.00	
Printing—Byron S. Adams..............................	13.00	
		$188.00
Excess of assets over liabilities..................................		$1,383.35

S. T. Dana,
Treasurer.

Examined and found correct:
Clyde Leavitt,
W. W. Ashe,
Auditing Committee.

February 1, 1912.

METHODS FOR REGULATING THE CUT ON NATIONAL FORESTS

BY BARRINGTON MOORE

Delivered before the Society January 11, 1912

In a paper which appeared in the last number of the Proceedings the "Essentials of Working Plans for National Forests" were treated in a very general and brief way; at the same time a promise was made that the salient points would be taken up more in detail in later papers. The Divisions of Area in Working Plans was discussed in the Forestry Quarterly for September, 1912. The Methods for Regulating the Cut on National Forests will be treated in the present paper.

I. Importance of Sound Silvicultural Methods

First of all, the importance of sound silvicultural methods of cutting should be emphasized. These methods are not at all dependent on regulation of the cut; they can be applied where there is no regulation whatever. On the other hand, it is possible, and has sometimes been done in other countries, to regulate the cut in such a way as to secure an equal annual or periodic sustained yield without first obtaining a thorough understanding of the silvicultural requirements of the tree and of the methods of cutting best adapted to securing its maximum production. In this case an equal sustained yield is obtained for most or the whole of the first rotation, but the productive capacity of the forest is steadily lowered. This is manifestly poor policy. A thorough understanding of the silvicultural requirements of the different trees and of the methods of cutting which will result in a maximum production of the most valuable ones is the first essential. In the long run it is generally far better to have over-cutting under proper silvicultural methods than to have a perfect regulation of the cut with poor methods of silviculture.

II. Object of Regulation and Where Necessary

The object of regulation is to secure an equal or approximately equal annual or periodic sustained yield of material from the forest. This is not at all necessary in some cases and essential in others. In general

the conditions under which sustained yield is not necessary, and those under which it is essential are as follows:

a. Sustained yield is not necessary.

1. Where the community forming the natural market for the timber is not dependent on National Forest material—that is, where material can be brought in from outside as cheaply as it can be produced locally. For instance, let us suppose the local market to be situated on a railroad, to be small, using only 2,000 M feet per year; and, furthermore, let us suppose that the region tributary to this market is capable of giving a sustained yield of but 4,000 M feet, and is moderately difficult to log. In this case it will cost just as much, and sometimes even more, for small operations, cutting only 2,000 to 4,000 M feet per year, to put their lumber on the local market than it would to bring the lumber in by rail or water from some larger operation where it is produced more cheaply. The solution will here be occasional large sales followed by periods of inactivity.

Even here sustained yield will be safer because of the danger of a discontinuance of the larger operations.

2. Where there is no local market for the timber, and not likely to be one for many years, and where furthermore the possible annual sustained yield is too small to warrant the building up of a community dependent solely on lumbering. Here occasional large sales creating temporary communities will be unavoidable.

b. Conditions under which sustained yield is essential.

1. Where a local community is dependent on a National Forest for its supply of forest products (building material, fuel, mine props, etc.). This may be a community situated away from a railroad, or one on a railroad where the freight rates are so high that lumber brought in costs more than lumber produced locally.

2. Where, although the product itself is not needed for local consumption, there is a community dependent on lumbering for a means of livelihood, and where, furthermore, the supply is sufficient to give sustained yield under operations large enough to secure the most economical methods of logging.

In some cases sustained yield, however desirable, may be impossible of attainment, for the present at least. For example, on an area so remote from transportation that it requires an expensive railroad or flume to open up, and containing so little timber that no lumberman would undertake to operate in it unless he could be assured of securing practically the entire amount, sustained yield cannot be brought about for a felling period, or perhaps for a whole rotation.

Eventually some form of regulation, even though it secure a yield separated by long intervals, which will none the less be sustained yield, will, it is hoped, be applied to all National Forests. But for the present only on those Forests, or parts of Forests, where the need is most urgent, can the work of regulation be undertaken.

III. Unit of Regulation or Working Circle

The unit on which to regulate the cut for the purpose of obtaining sustained yield should be *that area tributary to a certain market or outlet.* This will practically always be a main watershed. There will generally be several such areas on each National Forest. When the adjacent parts of two Forests form such a unit or working circle these parts (not the two whole Forests) should be regulated as a single working circle. Belts of protection Forest, in which no cutting is to be allowed, should be included in their proper working circle, but should be ignored in the regulation of the cut. Inaccessible areas, which, however, will become accessible in the first rotation, should be included in their proper working circle and considered in the regulation of the cut. As more intensive methods of management become possible the unit or working circle can be made smaller, to depend on silvicultural treatment as well as upon markets or outlets.

Where a market draws on a large territory, such as several National Forests, it will be advisable to split up this territory into several working circles each comprising a main watershed tributary to a certain outlet. But each working circle should be capable of yielding a permanent supply cut under sales large enough to permit the most economical methods of logging. In this way, at the outlet of each working circle contributing its quota to the central market there will be a permanent lumbering community. If, on the other hand, each watershed were cut off in turn there would be a single large but transient and undesirable community instead of a number of smaller but permanent and desirable ones. The unnecessarily large unit also has disadvantages from a purely silvicultural point of view. If the stand is even-aged, it results in two large even-aged blocks subject to damage by wind, fire, or insects; and, by rendering it impossible to promptly utilize the over-mature injured stands which need immediate cutting, the large unit causes waste.

In subdividing the working circle, the larger subdivisions should generally be called blocks. These can later be subdivided, as the management becomes more intensive, into compartments. For most cases at present, however, the subdivision into blocks will suffice. These sub-

divisions should be coördinated as far as possible with the administrative divisions of the Forest.

IV. Methods of Regulation

The choice of a method of regulation must depend almost wholly upon the kind of forest and the silvicultural system called for. (*a*) If the forest is *uneven-aged,** requiring a selection system (or group selection system), regulation must be on the basis of volume with an area check, the volume determined by a formula or by straight calculation; or on the basis of number of trees, with an area check, called the "single tree method." (*b*) If a forest is *even-aged* and the silvicultural system called for is a form of clear cutting or successive regeneration cuttings (the shelterwood compartment system), regulation should be based on area with a volume check or on volume with an area check, the former being preferable wherever possible. In this kind of a forest formulæ are unnecessary and should generally be avoided.

If, as is often the case, a single working circle contains both even-aged and uneven-aged forests, the method of regulation will be based upon the kind of forest from which most of the yield is to be obtained. At the first revision of the plan it may be possible to do away with the inconveniences caused by this makeshift form of management by making each of the two kinds of forest into a distinct working circle.

The methods of regulation for the two kinds of forests are as follows:

(*a*) *Regulation for Uneven-aged Forests*

There are five practicable methods of regulating the yield in uneven-aged forests:

1. The Austrian formula.
2. Hundeshagen's formula.
3. Von Mantel's formula.
4. The French method.
5. The single tree method.

1. *The Austrian formula.*—This formula is as follows: $Y = I + \frac{Gr - Gn}{x}$

* A forest of intolerant trees mads up of small even-aged groups, each group representing a different age class, should be considered *uneven aged*, provided the groups are, in the main, small enough to be treated as single trees.

Where:

Y = annual yield.
I = annual increment.
Gr = real growing stock.
Gn = normal growing stock.*
X = number of years within which to distribute the surplus (or deficit as the case may be).

The principle of the formula is that the annual cut will remove the normal increment, plus or minus the difference between the real and the normal growing stock represented by the expression $\frac{(Gr-Gn)}{x}$. If the stand contains more than the normal growing stock this surplus will be removed in as long or as short a period as desired, represented by X in the formula. If, on the other hand, the stand contains less than the normal increment the expression $\frac{(Gr-Gn)}{x}$ will become a minus quantity, and less instead of more than the increment will be removed till a normal growing stock has been obtained.

The normal growing stock (Gn) is first determined by the formula $Gn = \frac{I \times R}{2}$ where R = the rotation. This will give a growing stock supposed to be made up of all trees, the small as well as the large. If, as is almost always the case, the real growing stock (Gr) is made up of only merchantable trees it will be manifestly unfair to compare with this real growing a normal growing stock, which includes the small as well as the large trees. The result would be too small a surplus or too large a deficit. To obtain a more correct surplus or deficit a normal growing stock which includes only the merchantable trees should be used. This can be found by substituting for R in the expression $\frac{I \times R}{2}$ a quantity, R′, equal to the difference between the age of the merchantable trees and the rotation. For example, if the rotation is 200 years, and trees become merchantable at 60 years, the growing stock of merchantable trees necessary to leave on the area would be $\frac{I \times 140}{2}$ instead of $\frac{I \times 200}{2}$. If, as is often necessary, the real instead of the normal increment be used, the expression will still not give the correct growing stock. In most virgin forests the increment is low and will therefore give too low a growing stock. This will mean too high a surplus or too low a deficit. On the

* This growing stock is normal only if the increment (I) is normal.

other hand the allowable cut of increment in the final formula will be too low and will therefore tend to counterbalance the high cut of surplus. If this cut of surplus is distributed over a fairly long period, such as a quarter or third of the rotation, the error can work no great injury. When the increment is known to be too low it is unwise to try to correct the error by using R (the whole rotation) instead of R′ (the difference between the age of the merchantable trees and the rotation). The whole rotation will give a growing stock which is actually more correct, but mathematically incorrect and hence uncertain; it may be too large or too small. It will also give too low a cut because the low cut of increment in the final formula will not be counterbalanced by a high surplus.

The great advantage of the Austrian formula is its elasticity. The provision for distributing the surplus or deficit over as long or as short a period as is desired makes it possible to be very radical or very conservative. To be on the safe side and to forestall possible errors it is generally well to distribute the surplus over a longer period than is actually thought necessary. Since the working plan must be revised within ten or twenty years any mistakes which the formula will have caused one way or the other will not have sufficient time to do material harm.

The data required for regulating by the Austrian formula, in addition to the maps, forest description (by watersheds), silvical data, and utilization data (including markets, transportation, and logging costs) required for every method of regulation are:

The total volume (this will be the real growing stock).

Growth figures (either volume growth or growth in height and diameter. If only growth in height and diameter are obtained, a volume table must be secured in order to find the growth per cent).

With only the above data it will be necessary to find the increment by multiplying the total volume by the growth per cent. Of course, this growth per cent should represent the growth of only the merchantable trees. The resulting increment will be too low, since it fails to take into account the small trees not included in the estimate of volume because below merchantable size. The error will give too large a surplus growing stock, but will be counterbalanced to a certain extent, as indicated above, by too small a cut of increment.

The increment can be obtained more accurately if, in addition to the above data, the following be secured:

A type map.

Figures showing the area (or proportion of the type) *occupied by growth below merchantable size.*—These can be obtained by sample plots; or, if a strip method of estimating is used, the tallyman can note at the

end of each forty what per cent of the strip, exclusive of blanks, is covered with growth below merchantable size.

The increment per acre of this young growth.—This can be found by determining the number of merchantable trees per acre which there would be if the stand were about normally stocked (making due allowance for natural openings) and contained no other age classes. The volume of such a stand divided by the average age of merchantable trees will give the increment per acre of the young growth below merchantable size.

This increment, added to the increment of the merchantable stand, will give a close figure on the total actual increment of the type. To find the correct growing stock of merchantable trees this increment should be multiplied by $\frac{R'}{2}$ (half of the difference between the age of the merchantable trees and the rotation) rather than by half of the rotation.

The increment of the merchantable trees can be secured a little more accurately by constructing a stand table, if such a thing is possible, than by using a growth per cent.

The above data, with a stand table, can be made to give the normal increment. This is obtained by eliminating from the stand table the over-mature and 50 per cent of the mature trees (determined by diameter), and by substituting for the increment of the eliminated trees that of an area of young growth equal to the area occupied by the eliminated trees. The resulting increment will be the normal increment.

2. *Hundeshagen's formula.*—This formula is as follows: $Yr = Gr \times \frac{Yn}{Gn}$.

Where:

Yr = real yield.
Gr = real growing stock.
Yn = normal yield (or normal increment).
Gn = normal growing stock.

The principle of the formula is that the real yield must bear the same relation to the real growing stock as the normal yield (or normal increment) bears to the normal growing stock. It tends to reduce automatically any surplus or deficit in the real growing stock; but if the normal growing stock is found by the expression $\frac{I \times R}{2}$, it will require half of the rotation to do so. The formula will give the same result as the Austrian formula if Gn is figured by $\frac{I \times R}{2}$ in both, and if the surplus or deficit in the Austrian formula be distributed over half of the rotation.

The data required are the same as for the Austrian formula.

The principal disadvantage of Hundeshagen's formula (which is particularly a handicap in dealing with figures known to be subject to error) is that it gives no latitude in the choice of a period over which to distribute the surplus or deficit. The formula is, therefore, inferior to the Austrian formula and will not be of great use except as a check upon results obtained by other methods.

3. *Von Mantel's formula.*—This formula is as follows: $Y = \frac{V}{\frac{1}{2} R}$.

Where:

$V =$ total volume.
$R =$ rotation.

This formula is based upon the same principle as Hundeshagen's formula. Only in this one the growing stock is considered as the real increment (mean annual) multiplied by half of the rotation $\left(\frac{I \times R}{2}\right)$ Hence it gives the same result as Hundeshagen's when Gn is found by the expression $\frac{I \times R}{2}$. It also gives the same result as the Austrian formula when Gn has been determined by $\frac{I \times R}{2}$, and the surplus distributed over half of the rotation. If R′ (the difference between the merchantable age and rotation) is used in Von Mantel's formula, instead of R, the yield will be the same as that given by the Austrian formula in which Gn is found by the use of R′ and the surplus distributed over $\frac{R'}{2}$ years.

The great advantage of Von Mantel's formula is that it requires only the total volume and the rotation, and can therefore be used with rough data to which the other formulæ cannot be applied. It tends to automatically reduce any surplus or deficit, but requires half of the rotation to do so. Its disadvantages are (1) lack of elasticity, in that it does not allow the exercise of judgment in distributing the surplus or deficit; (2) it gives too low a cut. This is because the growing stock used in the formula is supposed to be the total volume on the area, both young growth and merchantable trees. But since in practice only the volume of the merchantable trees can be determined, the result will be too small. This is avoided by using R′ instead of R, where it can safely be determined. The formula will be of great value in regulating the cut provisionally before detailed data can be obtained, and in checking results obtained by other methods.

Under any of the above formulæ the area check is applied as follows: Divide the working circle into blocks, each block being a watershed containing one or more logging units.* Allot a certain number of years for the cutting of each block, according to the proportion of the total volume which it contains. The total cut over the whole working circle for the felling period will, of course, be the yearly increment multiplied by the felling period, plus the surplus or minus the deficit to be removed in the period.

4. *The French method.*—The use of formulæ in regulation based on volume with an area check may be avoided by the French method (in France called the procedure of 1883). This method is considered better adapted than any other to the treatment of uneven-aged, irregular mountain forests. It presents very little more difficulty than formulæ based on ample data.

The method is as follows:

The data required are the same as given above for the Austrian formula applied by means of a stand table. But instead of constructing a stand table the total volume of each diameter class should be determined. Some figures should also be obtained showing the number of trees of the diameter desired at the end of the rotation (exploitable diameter) which there would be per acre in a normally stocked stand, if no other age classes were present. Since these figures must be taken in the field, sometimes before the exploitable diameter has been decided upon, several diameters should be taken.

When the desired exploitable diameter has been decided upon, determine from the growth figures the number of years necessary to produce this diameter. This number of years, lengthened by a few years to allow for a possible delay in reproduction, will be the rotation.

Divide the trees shown by the estimates into three groups as follows:

1st group, old trees. Those containing two-thirds of the exploitable diameter and above; *e. g.*, if the exploitable diameter is 30″, this group would contain trees between 20″ and 30″.

2d group, medium trees. Trees having a diameter falling between one-third and two-thirds of the exploitable diameter; *e. g.*, trees between 10″ and 20″.

3d group, young trees. Everything with a diameter less than one-third of the exploitable diameter.

* This division into blocks should be made before the calculation of the yield, since it is sometimes advisable to make the calculation separate for each block. As a matter of fact the division should generally be made in the field to serve as a basis for forest description.

The calculation of the yield is based on groups 1 and 2, and is made in the following manner:

Find the volume of each of the first two groups. Then if the volume of the old trees is to that of the medium trees as 5 is to 3, the proportion of the two groups may be considered normal.* If the proportion is normal it will be possible to cut the group of old trees, plus their increment, during the first third of the rotation, the increment, of course, being figured for only half of the third of the rotation.

But, first of all, it is necessary to ascertain whether or not the volume as a whole is too great or too small. This is done by finding the total volume which there would be if half of the entire area were covered with trees of just exploitable size* (not of very large mature trees). In obtaining this volume the number of exploitable trees per acre, called for above, is used. The result should be approximately equal to the sum of the old and medium trees. If the result is less the forest contains a surplus; if more, it contains a deficit. There are five distinct possibilities:

(1) The volume of the old and volume of the medium trees may be in the proportion of 5:3, and sum of their volumes normal. In this case nothing further is necessary before the actual calculation of the cut.

(2) The volume of old and medium trees may be in the proportion of 5:3, but their sum less than normal. In this case it will be necessary to increase the growing stock. This can be done by cutting, during the first third of the rotation, only the old trees, without their increment, or, if the area is very badly understocked, by cutting less than the old trees.

(3) The volume of old and medium trees may not be in the proportion of 5:3, and their sum nevertheless normal. This is adjusted by transfers from the group which is too large to that which is too small.

* In dealing with open stands, such as Western Yellow Pine in the Southwest, the area must be considered as fully stocked with exploitable trees, but due allowance must be made for natural openings and bare places.

(4) The volume of old and medium trees may not be in the proportion of 5:3, and their sum less than normal. This will probably mean that the volume of old trees is deficient, and must be increased by cutting less than the otherwise allowable volume of old trees.

(5) The volume of old and medium trees may not be in the proportion of 5:3, and their sum more than normal.

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* This ratio is, of course, only approximate; it will vary with the length of the rotation, the conditions of growth, and the species, but it is sufficiently exact for all practical purposes.

This could occur only with an excess in the old group. To correct this, find the volume of old trees necessary to make the ratio 5 : 3 with the volume of the medium trees, and which, added to the volume of medium trees, will give a normal growing stock. The difference between this volume and the actual volume of old trees is surplus. This surplus must generally be removed during the first third of the rotation, for the entire area will be cut over once during that time. Even though it were desirable to distribute this surplus over a longer period, such a course would generally be impossible, because in virgin forests, most of them of difficult accessibility, the first cut must be heavy per acre to justify logging. Later cuttings may, without hardship to purchasers, be made lighter.

When several species occur in mixture all are regulated together without affecting the method. If one species has a more rapid growth and is shorter lived, requiring a shorter rotation, its exploitable diameter should be made lower than that of the other species.

The whole calculation is checked by figuring what per cent of the total volume is represented by the allowable cut. This per cent, after subtracting the surplus, should be approximately the growth per cent of the group of old trees.

The area check on this method is applied as follows:

The whole working circle is to be gone over in one-third of the rotation. Since the rotation may be long, this third is further divided into periods during which the plan is to run without revision. If these periods are too short an unnecessary expense will be incurred by frequent reconnaissance work, whereas if they are too long there is danger that the effects of original errors may accumulate. A period of about 20 years seems reasonable. Thus if the rotation is 180 years, the whole working circle will be cut over in 60 years. If the period during which the plan is to run be 20 years, the area is divided on the basis of topography into three parts, each containing about an equal volume, and each to be cut over in 20 years. In some cases, where the working circle does not lend itself to a division into parts containing equal volumes, it may be divided into unequal parts, each part to be cut over in a period bearing the same relation to the one-third of the rotation as the part bears to the whole working circle. The part containing the largest proportion of overmature and deteriorating timber should be cut during the first period. This part may be further subdivided for convenience into watersheds forming natural logging units or groups of units.

The following example of the French method is given for the sake of clearness:

Total area of working circle = 200,000 acres.

Minimum merchantable D. B. H. = 10″.

Size of material desired: Sugar pine and yellow pine = 30″. Incense cedar = 24″.

The group of old trees will include those 20″ and over D. B. H. The medium trees will include those between 10″ and 20″ D. B. H.

The average length of time required to produce a tree 30″ D. B. H., considering the important species, is 160 years. The period of reproduction is approximately 20 years. Hence the rotation will be 160 + 20, or 180 years. Incense cedar is shorter lived and more rapid growing, hence will be considered exploitable at 24″.*

TABLE OF ESTIMATES

Medium Trees | *Old Trees*

Volume M feet					Volume M feet			
Sugar pine	Yellow pine	Incense cedar	Total	D. B. H. inches	Sugar pine	Yellow pine	Incense cedar	Total
Volume of sugar pine and yellow pine for each diameter class up to 19″, inclusive.		Volume of incense cedar for each diameter class up to 15″, inclusive.	200,000	10 11 12 13 etc.	Volume of sugar pine and yellow pine for each diameter class, 20″ and over.		Volume of incense cedar for each diameter class, 16″ and over.	1,800,000

From the table we find the actual proportion of old and medium trees to be:

Old trees = 1,800,000 M feet
Medium trees = 200,000 M feet

Total, 2,000,000 M feet

The normal proportion should be:

Old trees, $2{,}000{,}000 \times \frac{5}{8} = 1{,}250{,}000$
Medium trees, $2{,}000{,}000 \times \frac{3}{8} = 750{,}000$

* This exploitable diameter for incense cedar will cause a slight inaccuracy in that the medium trees should be taken to 8″ instead of 10″ to correspond with the 24″. On the other hand the volume between 8″ and 10″ will be small, and if desired can be allowed for by sample tallies over a small percentage of the strips. The cutting of a short-lived species to a lower diameter limit is desirable in this case because the area is gone over only once in 60 years.

But the normal growing stock over the whole area, considering half of the area stocked with 30″ trees, should be 1,120,000 M. This should be divided between the two groups as follows:

$$\begin{aligned} \text{Old trees, } 1,120,000 \times \tfrac{5}{8} &= 700,000 \text{ M.} \\ \text{Medium trees, } 1,120,000 \times \tfrac{3}{8} &= 420,000 \text{ M.} \\ \hline & \ 1,120,000 \text{ M.} \end{aligned}$$

Hence, although there is a surplus of 1,800,000 — 700,000 = 1,100,000 M feet of old trees, there is a deficit of 420,000 — 200,000 = 220,000 M in the medium trees. If all the old trees were cut during the first third of the rotation the growing stock would be depleted. Therefore 220,000 M feet will be taken from the lower diameters of the large trees, chiefly from the more valuable species, and added to the medium trees. The resulting surplus will be 1,100,000 — 220,000 = 880,000 M. This surplus is to be removed during the first third of the rotation. The cut for the first third of the rotation will therefore be the 880,000 M surplus and the 700,000 M normal volume of old trees, plus the increment on their sum. This increment will be 12,000 M per annum, or 12,000 x 30 = 360,000 for the 60-year period.* Therefore the annual cut for the first third of the rotation will be:

$$Y = \frac{800,000 + 700,000 + 360,000}{60} = 32,333 \text{ M feet.}$$

This amounts to 1.61 per cent of the total volume. Not counting the surplus or increment on the surplus, there will be a cut of only 853,000 M feet for the 60-year period, or an annual cut of only 14,216 M feet. This is but .71 per cent of the total volume, or approximately the increment on the group of old trees.

In carrying out this method, site qualities producing very marked differences in growth must be distinguished in the field work and kept separate in the computations. For instance, in some of the very dry limestone soils of the Western Yellow Pine belt of the Southwest the trees are small and stunted, and even when mature hardly reach the diameter of poles on ordinary sites. Such areas if small and unimportant may be thrown out and ignored; but if of some extent they should generally receive a separate calculation of yield and proper consideration in the final allotment of the cut.

In marking, the exploitable diameter need not be rigidly adhered to. Injured, suppressed, or stunted trees below the limit may be cut. But at

* The increment is taken for only half of the period because cutting is going on.

the same time the marking officer should always strive to leave in the form of thrifty trees above the diameter limit enough material to counterbalance those trees below the diameter limit which he has removed. This balance need not be kept on small units, such as a few acres, but should be carefully maintained over considerable areas. In this way differences of site qualities will to a certain extent be equalized.

In order to keep a check on the diameter classes cut, it might be well for the marking officer to tally the diameters of all trees marked and of those above the diameter limit which he leaves. At least he should keep track of those below the limit marked and those above the limit left, so that he may see how the two balance.

A disadvantage of the French system is that it requires the tallying of trees down to one-third of exploitable diameter. This means that if the exploitable diameter is 24″ everything above 8″ must be tallied. It is, therefore, best adapted to a high diameter limit and long rotations, which is, however, generally the case in many of our selection forests. The advantages of the method are elasticity and a degree of accuracy not attainable with formulæ.

In a forest managed under the selection system, with any of the above methods of regulation, it is obvious that great care must be exercised in the markings to avoid on the one hand a too great reduction of the growing stock, and on the other hand a leaving of the area encumbered with a more or less unproductive surplus. Hence the provisions of the regulation must be guarded by a well-founded silvicultural system and carefully drawn up set of marking rules. For instance, if the plan provides for cutting over the entire area every 40 years, a certain number of thrifty trees must be left standing in order to furnish the second cut at the end of 40 years. Hence the marking rules should stipulate that no thrifty trees which, from their appearance, are growing well and are sure to live 40 years should be marked, even though they are large enough and though the allowable cut for the area is not obtained, and vice versa, that no mature trees which will not surely live 40 years be left, even though the allowable cut be exceeded. In most virgin uneven-aged forests the over-mature and mature trees will generally give ample material for the first cut. In this way errors due to inaccuracies in the estimate of volume or in the growth of figures will not result in injury to the forest. At the same time the prescribed volume will prevent a blind overcutting, which might be disastrous to industries or communities dependent upon the forest.

5. *Single tree method.*—This method is based on the principle that a certain number of trees reach a size suitable for cutting every year or

period of years. The aim of the method is to cut just this number of trees.

The data required are:

1. A careful enumeration of the growing stock. For this purpose five or six broad classes are made from seedlings up to mature trees.

2. Growth figures, particularly showing the number of years required to pass through each class.

3. Figures showing the percentage of mortality suffered by each class as it passes into the next class above and into the final or mature class.

The rotation is generally the sum of the number of years required to pass through each age class till the exploitable size is reached, with generally a few years added on to make it conservative. The felling period is a convenient subdivision of the rotation and should be at least the length of time required to produce enough material to justify the next cut.

The annual cut is calculated in the following manner: The number of trees in each class is multiplied by the percentage which will survive till maturity. The results are added and then divided by the rotation plus one-half of the felling period.*

In order to find the growing stock of Class I trees the average annual yield as found above is multiplied by half of the felling period. In order to allow for mortality this number is raised by multiplying by

$$1 \times \left(\frac{\text{Mortality per cent}}{2}\right).$$

The growing stock thus found is compared with the actual growing stock to find whether there is a surplus or deficit. The annual cut is allotted accordingly, distributing this surplus or deficit over a certain period according to the proportion of lower classes and reproduction.

The area check is applied by prescribing the order of the fellings through the different subdivisions (compartments) of the working circle. A table is drawn up showing for each year the subdivision on which the cut is to be located and number of trees to be removed.

A concrete example will serve to make the method clear:

* Half of the felling period is added to the rotation to allow for the number of Class I trees (the largest class) which should always be on the ground, because there should always be a number of Class I trees equal to the $\frac{\text{Felling period}}{2} \times$ average annual yield.

TOTAL GROWING STOCK

Class

Species.	I. 28″ and over D. B. H.	II. 24″ to 28″	III. 18″ to 24″	IV. 12″ to 18″	V. 6″ to 12″	VI. Below 6″ D B. H.
Yellow pine	13,178	11,366	19,770	42,577	117,590	215,667

Rotation = 150 years
Felling period = 15 years

From a table showing per cents of each class, reaching Class I, and the per cent of Class I surviving 15 years, the following calculation is made:

$$\text{Average annual yield} = \frac{(13178 \times .95) + (11366 \times .83) + (19770 \times .66) + (42577 \times .50) + (117590 \times .30) + (215667 \times .10)}{150 + \frac{15}{2}}$$

$$= \frac{12519 + 9472 + 13180 + 21288 + 35277 + 21567}{157.5}$$

$$= \frac{113303}{157.5} = 719 \text{ trees per annum.}$$

The growing stock of Class I trees, which there should always be, is therefore $719 \times \frac{15}{2} \times 1.025 = 5532$.

Since there are 13,178 Class I trees, a surplus of 13,178 — 5,532 = 7,646 trees exists.

The cut for the period over which it is desired to distribute the surplus will be: The present Class I trees, plus the total number of trees reaching Class I in the period, minus the growing stock, all divided by the period.

A modification may be made by calculating the annual yield on the basis of only the upper classes (the first three or four) instead of on all classes. The sum of these classes is then divided by the number of years which the lowest class used will take to become Class I instead of by the rotation.

Practically the only place where the single tree method is used is in India. There it is used almost to the exclusion of all other methods. It is particularly well adapted to mixed tropical forests in which only one or two of the many species found is merchantable.

The disadvantages of the method are its lack of elasticity, its complexity, and liability to error; it also requires as much data as better

methods. Hence it should be used only in exceptional cases. The French method is greatly to be preferred wherever possible.

(b) Regulation for Even-aged Forests

Of the two kinds of forest—uneven-aged and even-aged—the latter is by far the more important, both from the point of view of area and of timber produced. Its regulation is also simpler, considering it in the long run, and less subject to error.

The two methods of regulation applicable to even-aged stands are:

(1) By area with a volume check.

(2) By volume and area.

The two methods are similar in many respects, but will be described separately.

(1) ***Area with a volume check.***

The data required are:

Distribution of age classes (shown on a map).

Forest types (also on a map).

These should be not only the permanent types, but also temporary types important in management and which it is desirable to perpetuate.*

Site qualities, three will generally suffice.

Volume, as accurate estimates as possible.

Growth, best arranged in the form of yield tables for different types and site qualities.

Area of each age class; this is actual area. For final use it will be reduced to areas of equal productivity.

The principle of the method is simple. It is to cut each year or period of years an equally productive area containing an approximately equal volume. It is more important to cut an equally productive area than an equal volume, because the equally productive area will give a normal distribution of age classes and equal sustained yield in the next rotation, whereas cutting an equal volume may, through present irregularities in the stand, lead to irregularities in the next rotation.

In applying this principle the first step is to decide upon the rotation. The second step is to tabulate the area of the age classes according to site quality*—*e. g.,* with rotation of 120 years.

* Physical factors are, of course, the basis of permanent forest types. But to use them in this case would make forest types correspond with site qualities and would ignore temporary types, such as Douglas Fir on the Pacific Coast and Western White Pine in Idaho, which are of the utmost importance in management and which should be perpetuated.

* Other data, such as block descriptions, logging conditions, etc., can well be summarized in a table.

Age.	Area, acres.				Volume, M feet.				Increment per acre per annum (board feet).		
	Site qualities**			Total area of age classes reduced.	Site qualities.			Total volume.	Site qualities.		
	I.	II.	III.		I.	II.	III.		I.	II.	III.
120 +											
110											
100											
90											
Totals											

** Site qualities on basis of productivity $\begin{cases} \text{I} = 1.0 \\ \text{II} = .7 \\ \text{III} = .4 \end{cases}$

(Just as an example. Actual figures will vary in each case.)

From this table the area to cut annually is obtained by dividing the total reduced area by the rotation. The volume of the annual cut will likewise be the total volume divided by the rotation.* This cut cannot, however, be rigidly applied, but should serve as a general guide.

Since the allowable *annual* cut of area and volume thus calculated will be difficult to enforce, the regulation must generally be based on *periods* of 10 or 20 years.

The allotment of the area and volume to cut in each period is shown in a table which gives the detailed allotment for only the first two or three periods and general allotment for the remainder of the rotation. The blocks made under Forest Description will serve in locating the cut.

The table should follow as closely as possible the accompanying model, with only such modifications as local conditions render unavoidable:

* The theoretical normal cut would be the total reduced area multiplied by the normal yield per acre and divided by the rotation.

Allotment of the Cut

Period	Administrative division (i. e., ranger district)	Blocks	Area			Total actual area	Total area reduced	Volume at time of cutting				Age at time of cutting				Remarks (condition of timber, etc.)
			Site qualities					Site qualities				Site qualities				
			I	II	III			I	II	III	Total	I	II	III	Average	
I. 1911–'20	Barclay	I														
	Bear Creek ..	III IV V														
	Dalton Creek	VII														
		Total average annual.														
II. 1921–'30	Barclay	I II														
	Bear Creek ..	IV V VI														
	Indian Creek	IX X														
III. 1931–'40																
IV. 1941–'50																
etc.	Totals........															

The allotment after the first 20 or 40 years need not be made in detail. The total area and volume, and average age, will suffice; for the plan will almost certainly be revised by that time.

The allotment of areas and age classes to different periods in the rotation, as in the above table, may present some difficulties. For example, a forest may contain so much young growth and so little mature or exploitable timber that it will be impossible at first to cut the allowable area without including some of the younger-age classes. In this case careful judgment and a thorough knowledge of silvicultural and market conditions will be needed to decide whether it will be best: (1) to distribute the mature timber over the period before the next age class will be exploitable; or (2) to cut this mature timber and wait; or (3) to sacrifice some of the younger but still merchantable timber in order to supply the market continuously and secure a normal distribution of age classes in the next rotation. Sacrifices of large amounts of young timber solely to secure a normal distribution of age classes are justified only when this distribution is based on very accurate data. On the other hand, forests containing an excess of the older-age classes will present no difficulties in cutting the allowable area, except the possibility of selling the timber; in this case the only disadvantage of regulation will be the loss through deterioration caused by distributing over a greater or less period of years stands already ripe. This loss will, however, be less than without regulation; for without regulation it is almost impossible to tell accurately which stands are most in need of cutting, and therefore the vigorous mature stands are often cut and the over-mature deteriorating stands left.

The above method can be applied with any silvicultural system adapted to even-aged stands, whether it be clear cutting and planting, clear cutting with seed trees, or successive regeneration fellings (shelterwood compartment system). In the last case the periods into which the rotation is divided should be equal to the period of reproduction.

(2) *Volume and area.*

The essential difference between this and the first method is that the aim of the first method is to secure equally productive areas, with volume as a secondary consideration, whereas the aim of this method is primarily to secure an equal volume.

The data necessary are the same except that for site quality (on which productivity depends) is substituted normality, which includes stocking of the area as well as site quality. The standard of normality is the ability to produce a certain volume per acre at the end of the rotation.

As soon as the rotation has been decided upon a preliminary table should be constructed showing the area of each age class and its normality.

Age.	Area, acres, for each normality.								Total area of age class on basis of 1.0.
	.3	.4	.5	.6	.7	.8	.9	1.0	
10									
20									
30									
40									
etc.									

On the basis of this table another is constructed showing the area, actual and reduced to normal, and the volume maturing in each decade. The sustained yield by decades will then be the total volume maturing in all decades of the rotation divided by the number of decades in the rotation. But since the volume maturing in each decade will vary greatly, and since the forest will generally contain an overstock or understock of mature timber, it is advisable to group the decades and to calculate the cut for each group of decades by dividing the volume maturing in the group by the number of decades in the group, instead of calculating it for the rotation as a whole. This will also be more conservative in that errors due to forecasting the future volume of present young stands will not enter into the present allowable cut. These errors will, of course, be greatly minimized when the plan is revised. The area to cut each decade is the actual area which will produce the allowable volume.

The above method is applicable to successive regeneration cuttings, as well as to clear cutting systems. For example, an area of 4,500 acres, containing 27,000 M feet, is to be cut over in 30 years. The yield per decade is 9,000 M feet, or 900 M feet per annum. Under a clear cutting system 150 acres, containing 900 M feet, would be cut over each year. Under a system of three successive regeneration cuttings 10 years apart, the same volume would be cut each year, but it would require approximately three times the area, or 450 acres, per annum to give this volume. The 4,500 acres would be cut over once every 10 years, or three times during the 30 years, until at the last cutting regeneration is complete.

From the foregoing it will be evident that between area regulation, with a volume check and volume and area regulation (as outlined above), there is but a short step. This step should be taken wherever possible, because regulation by area with a volume check is safer and simpler and the ultimate goal for even-aged forests.

Volume regulation with an area check could, of course, be applied to even-aged forests by methods different from the above. It is possible, if age classes cannot be mapped, to use any of the formulæ given for uneven-aged forests, or even the single tree method. Such methods should, however, be avoided wherever it is possible to map the age classes and secure sufficiently reliable yield tables.

V. Execution and Control of Plan

For a plan of regulation to be effective one officer must be charged with its execution, and a record kept of the provisions of the plan and manner in which these provisions are actually carried out. The Forest Supervisor is the logical officer on whom responsibility for the execution of the plan should rest, and the record should be kept in a control book. There should be a separate control book for each working circle, and each book should be arranged with one page for each block or compartment of the working circle. If there are both blocks and compartments, there should be a separate page for each compartment. Each page should show for each year the prescriptions of the plan, actual operations, and a comparison between the two. It should also show areas planted or sown and receipts and expenditures. When thinnings become possible, these also can be included. An example of a page in the Control Book is given below. This is for regulation by area with a volume check; if regulation is by volume with an area check slight modifications will be necessary. The "year" column need include only the years for which the plan is to be in force before being revised.

Headings for a Page of the Control Book.

Year.	Area of block or compartment.		Volume on block or compartment.			Prescriptions of plan.						
						Area to cut.		Volume to cut.			Volume to leave.	
	Actual.	Reduced.	Each species.	Total.	Per acre.	Actual.	Reduced.	Each species.	Total.	Per acre.	Total.	Per acre.

Operation of plan.							Comparison, plus or minus prescriptions.						
Area actually cut.		Volume actually cut.			Volume left.		Area actually cut.		Volume actually cut.			Volume left.	
Actual.	Reduced.	Each species.	Total.	Per acre.	Total.	Per acre.	Actual.	Reduced.	Each species.	Total.	Per acre.	Total.	Per acre.

Reasons for deviation.	Planting.		Sowing.		Receipts.		Expenditures.
	Area.	Cost per acre.	Area.	Cost per acre.	Timber.	Grazing.	Each heading.

VI. Importance of Preliminary Reconnaissance

The choice of a method of regulation involves a thorough knowledge of the region to be regulated. The working plans officer must know, first of all, whether the forest is even-aged or uneven-aged; then whether part is even-aged and part uneven-aged, and, if so, which predominates; what forest types are to be dealt with, and, roughly, the silvicultural system called for. Upon all this will depend the method of regulation; and upon the method of regulation will depend the data to be gathered. Obviously upon the data to be gathered will depend the method of field work. Hence the field work depends directly upon a knowledge of the region and of its requirements. This knowledge can be acquired by the working plans officer in a month or two spent going carefully over the area before the regular field work begins, and is of such importance that no regular reconnaissance field work should be attempted before this preliminary reconnaissance has been made. Otherwise it is practically certain that insufficient or unnecessary data will be gathered, and that the results will therefore not be commensurate with the cost. It is also necessary for the working plans officer, after this preliminary reconnaissance and before beginning the regular field work, to discuss thoroughly with the Supervisor the method of regulation to be applied.

A rough idea of the size of the unit from which sustained yield is to be obtained (working circle) should also be had before beginning the field work. This involves a thorough familiarity with market conditions, lines of transportation, and the topography of the country. It will enable the work to be concentrated on one unit at a time, a distinct advantage in many cases.

PARASITISM OF PHORADENDRON JUNIPERINUM LIBOCEDRI ENGELM.*

BY E. P. MEINECKE

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Phoradendron juniperinum libocedri Engelm. on *Libocedrus decurrens* is a small hanging shrub forming a bunch of rather thin, slender, and brittle leafless stems; it is quite conspicuous, and is therefore familiar to any one whose duties or pleasure take him into the forests of the Sierra Nevada in California. Like most green *Loranthaceæ*, it is light-seeking, and therefore preferably nests high on the younger branches of the crown. Here it causes a more or less conspicuous swelling. This is the form under which it is commonly known.

Quite frequently the trunks of mature and over-mature specimens of *Libocedrus decurrens* show spindle or barrel-shaped burls or swellings, either all around the trunk or one-sided. The bark on these swellings is unusually rough; frequently the ridges are broken so that the burl takes on a canker-like appearance. The wood, however, it seems, is never exposed.

The first incense cedars with such burls I found on the Stanislaus Forest in the Sierra Nevada, California. Several of these swellings were opened, and a cross-cut revealed the presence of old plants of *Phoradendron juniperinum libocedri*. The sinkers were well preserved. In the heart wood, of course, all the sinkers were dead (plate I); in the sapwood and in the bark they were living (plate II), and on close investigation of the outer bark in a few cases very short and poorly developed stems of the mistletoe were found in the bottom of the deep bark furrows. On the larger swellings of older trees no green sprouts at all were found.

I. The first specimen examined was on a tree 40 inches diameter B. H., 111.7 feet high, and 221 years old. The thrifty, over-mature tree had several large open-fire scars and a few mistletoe bunches in the crown. The swelling began about 17 feet above ground. Not the entire cross-section was infected with mistletoe; the area in which sinkers were found covered an angle of about 130°. The sinkers appeared ar-

* By permission of the Secretary of Agriculture.

ranged more or less regularly in several concentrical rings. The trunk at a section 18.3 feet from the ground through the center of the swelling was 196 years old. One of the living sinkers of average length in the wood measured 7/8", growing through 19 years. Another living sinker in the wood, which reached the cambium, measured 1½", covering 36 years. The infected part of the swelling was 2 feet 9 inches long. No mistletoe sprouts appeared on the outside of the bark.

II. The second tree with mistletoe swelling measured 39 inches diameter B. H.; it was 105 feet high and 214 years old. This cedar was well isolated in an open stand of yellow pine, white fir, cedar and sugar pine. The tree was very thrifty, but had about 20 bunches of *Phoradendron* hanging from the branches. The tree seemed to have been frequently struck by lightning. A barrel-shaped mistletoe-swelling began at 27.6 feet above ground and measured 5 feet 8 inches in length. The actual mistletoe infection in the swelling had a length of 4 feet 10 inches. The infection covered only part of the cross-section. Measurements illustrate the fact that the heart wood on the infected side is formed much sooner than on the sound side of the trunk. In many cases the heart wood follows the sinkers into the sapwood with a dark lining.

The oldest sinkers were found about 4 inches from the center, covering 46 years. From there to the cambium are 114 annual rings, with numerous sinkers. The sinkers in the heart wood were more or less arranged in three rings, each about one inch broad. There were comparatively fewer living sinkers in the sap than dead ones in the heart wood. The growth in diameter was distinctly stimulated in the periods of heavy growth of mistletoe sinkers.

On this swelling I found three small stems of *Phoradendron* growing out through the bark, one toward the center and the other two on either end of the swelling. They measured one to two inches; the upper part of the longer one of these was dead. One of them was found, when a piece of the bark was split off, bent and recurved, trying in vain to push its way through the thick overlying bark.

III. Specimen No. 3 was an over-mature snag which had evidently been dead for many years. A huge open-fire scar had hollowed the butt and the trunk up to 17 feet high, so that no accurate determination of its age was possible; but to judge from its diameter of 45 inches, the tree may have been about 350 years old. On the trunk itself numerous mistletoe infections and swellings (over 20) were found, particularly so on the under side of older limbs, which showed the peculiar buttress-like swelling so frequently found on over-mature incense cedar. At a height of about 45 to 50 feet a swelling occurred which was found to be

caused by mistletoe. Old sinkers reached far into the heart wood toward the center of the trunk.

IV. This over-mature but thrifty tree stood on a gentle slope to west, quite near a small creek in an open stand of cedar of the same age. The crown was fairly well developed; the trunk was slightly leaning to the south and not quite straight, carrying many dead limbs on all sides and several mistletoes on living branches. There were two swellings on this tree; the lower one, at a height of 8 feet 9 inches, was by far more conspicuous than the second one, at a height of about 20 feet. The length of the lower swelling was 3 feet 7 inches; the circumference at the lower end was 122 inches, in the center of the swelling 131 inches, and at the upper end 98 inches. The swelling was decidedly one-sided. Upon close investigation one small living stem of mistletoe was discovered deep in a furrow of the bark covering the large swelling. This swelling was opened with a saw, and on the cross-section a mistletoe infection covering more than 230° appeared. All the sinkers in the heart wood were dead; a great number of living sinkers were found in the sapwood and in the living bark, where they formed long longitudinal rows. The tree at this cross-section was 256 years old. The first 37 years counted from the center were free of sinkers. The number of annual rings from the first sinker to the cambium gave 219 years as the age of the mistletoe infection in this part.

Since the time these observations were made I have found a great number of similar burls on the trunks of incense cedars of all ages above large pole size. On the younger trees the swellings show very little, and on closer inspection one will almost invariably find small and weakly developed bunches of *Phoradendron*, which, however, seem to be sterile. The older the tree the larger the swellings and the smaller and fewer the green mistletoe stems until these latter finally disappear completely.

In the field all stages are found. Young vigorously growing green shrubs of *Phoradendron* on branches cause only a comparatively small swelling. When growing on incense cedar trunks the root system becomes more important and the green shrub is reduced in size and development. On the trunks of older trees with thicker bark swellings of some extent are caused by the richly developed root-system, and only small shrubs consisting of a few short stems which no longer produce any flowers appear on the outside. Later, on over-mature trees, the green parts of the mistletoe plant are completely suppressed and the entire mistletoe plant living in large swellings of the trunk consists of a most complicated system of sinkers and cortical roots with numerous undeveloped adventitious buds.

The presence of old mistletoe plants in these swellings on incense cedar is interesting from more than one point of view. As far as the practical aspect of the matter goes, it is clear that a log containing mistletoe sinkers in great numbers must be valueless. Differences in tension cause the wood to split and check badly, the checks following preferably the broad sinkers.

The fact that *Phoradendron juniperinum libocedri* is far more long-lived than was supposed is of some interest. That certain mistletoes are able to reach a high age is well known. Tubeuf* states that often sinkers of *Viscum album* are found extending through 60 to 70 annual rings of growth. These are probably the oldest mistletoe plants on record.

In one of the preceding cases the mistletoe was still thrifty at an age of 219 years, and this age cannot even be correct, as the tree was 37 years old when the mistletoe first appeared in the trunk. The bark of an incense cedar of that age is impermeable to the sprouting embryonic rootlet of the mistletoe seed. The infection of the trunk must have come through a previously infected branch. In other words, the mistletoe plant in this case must have been a number of years older than 219; allowing conservatively about 10 years for the cortical roots to travel from the infected branch to the trunk, the age of this mistletoe plant would be about 230 years.

It is of particular interest to note that *Phoradendron juniperinum libocedri* when it reaches a high age lives without green exterior organs. In what way, then, does it secure its organic food?

We do not know anything definite about the degree of parasitism of *Phoradendron juniperinum libocedri* and its relation to its host with regard to the quality of the food material it derives from that source.

It is generally accepted that the chlorophyll containing representatives of the parasitic *Loranthaceæ*, such as for example *Viscum album* and the closely related *Phoradendron flavescens,* produce their organic food by photosynthesis, but are dependent upon their host for water and the inorganic salts it contains in solution. There seems, however, to exist considerable disagreement about how far this dependency of the green *Loranthaceæ* upon their host actually goes.

Bonnier* believed that *Viscum album* was nourished by one of its hosts, the apple tree, in summer and contributed food to the latter during

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* v. Tubeuf. Die Mistel, *Viscum album.* Pflanzenpathologische Wandtafeln, I: 12, Text and explanation. 1906.

* Bonnier, Gaston. Sur l'assimilation des plantes parasites à chlorophylle. Compt. Rend. *113*: 1074-1076. 1891.

winter. According to Hartig[**] the *Loranthaceæ* for the most part abstract only water and inorganic food from the tree they inhabit; we think it, however, not impossible that also plastic material is incidentally taken up. The same opinion, namely, that *Viscum album* and *Phoradendron flavescens* depend upon their host mainly for water and inorganic salts, modified by the assumption that perhaps they obtain part of their organic food from their host, is expressed by Zürn,[*] Cannon,[**] Peirce,[***] Heinricher,[#] York,[##] Bray,[###] and others. We also know, and this is important (Cannon (*l. c.*), Pierce[″]), that the phlœm of *Viscum album* and *Phoradendron flavescens* does not connect with the phlœm of the host. Cannon further mentions that the American mistletoe in its extreme youth is totally parasitic.

Two observations related by Heinricher[‴] have a closer bearing to our subject. A seed of *Viscum album* had germinated on *Pinus montana*, had entered the host, and had been living in it for 10 years before green shoots appeared on the outside. Another *Viscum album* had been living on *Nerium oleander* for 30 years and then apparently died off. Three years later the mistletoe had reappeared.

It is true that the authors mentioned had in view the leafy forms *Viscum album* and *Phoradendron flavescens*. *Phoradendron juniperinum libocedri* is leafless. This is, of course, not in itself sufficient proof that it should even partly depend upon its host for its supply of organic food as long as it possesses green assimilating sprouts. As soon as the entire plant is reduced to non-assimilating parts in the interior of the host, it must necessarily take all its food, organic as well as inorganic, from the host.

** Hartig, Robert. Lehrbuch der Baumkrankheiten, pp. 17-19. 1882.

* Zürn, E. S. Die Mistel, ein schädlicher Pflanzenschmarotzer auf Waldung Obstbaumen. Prakt. Blätter f. Pflanzenschutz. *3*: 19-21, 34-35. 1900.

** Cannon, W. A. The anatomy of *Phoradendron villosum* Nutt. Bull. Torr. Bot. Club. *28*: 384, 387. 1901.

*** Peirce, G. J. A textbook of Plant Physiology, p. 87. 1903.

Heinricher, E. Beiträge zur Kenntnis der Mistel. Naturwiss. Zeitschr. für Land-und Forstwirtsch. *5*: 357. 1907.

York, Harlan H. The anatomy and some of the biological aspects of the "American mistletoe" *Phoradendron flavescens* (Pursh). Nutt. Bull. Univ. Texas, No. 120; Scient. Ser. No. 13. p. 18. 1909.

Bray, William L. The mistletoe pest in the Southwest. U. S. Dept. Agr., Bur. Plant Ind., Bull. 166. 1910.

″ Peirce, G. J. On the structure of the haustoria of some phanerogamic parasites. Ann. Bot. *7*: 291-326. 1893.

‴ Heinricher, E. Experimentelle Beiträge zur Frage nach den Rassen und der Rassenbildung der Mistel. Centralbl. f. Bakt. II. *31*: 286. Oct., 1911.

Whenever the green parts of mistletoe plants are broken off or otherwise destroyed the cortical roots are stimulated to the development of new adventitious buds. This is as true for *Phoradendron juniperinum libocedri* as it is for *Viscum album* and *Phorandendron flavescens.* It is well known how difficult it is to get rid of *Viscum album* or *Phoradendron flavescens* in orchards or on ornamental trees simply by breaking off the green parts from time to time. Repeated destruction of the green parts also stimulates the growth of the root system. The roots remain alive for a long while; they spread in the living bark of the host and send out new sprouts. If normally green mistletoes really only take water and mineral salts from their hosts, the development of the root system and of the adventitious buds in such cases must take place at the cost of reserve material produced by the green mistletoe shrub. There is nothing improbable about the assumption that at least part of the ample supply of organic food produced by the sturdy and rather persistent leafy mistletoes, with their large assimilating surface of green foliage and stems, should be stored in their root system. It appears less clear how the root system should survive for a number of years when the green parts are systematically destroyed. The fact, however, that in spite of the prominent position the European and American mistletoes have held in the interest of the scientific world for so many years, no case of a mistletoe surviving for a greater number of years in the state of pure parasitism without any help from green shoots has been reported, points to the probability that after all the leafy mistletoes are not able to emancipate themselves completely from their own green assimilatory organs. In this connection it must be remembered that the cortical roots of *Viscum album* and *Phoradendron flavescens,* lying near the surface of the branch they inhabit, contain chlorophyll. These surface roots later die off when the formation of cork layers cuts off the outer parts of the bark from the water and food supply from the interior.

With the growth of the crown of the host tree the mistletoe is more and more cut off from the light as well. The green hemiparasites are all more or less sensitive to the lack of light (Heinricher*) ; it is quite possible that *Viscum album* and *Phoradendron flavescens* suffer more from this source than *Phoradendron juniperinum libocedri.*

Viscum album and *Phoradendron flavescens,* then, normally are hemiparasites, mainly dependent upon their host for their supply of water and inorganic salts, and probably able to a moderate degree to abstract from their host certain organic food material, which in the case of loss of the

* Heinricher, E. Die grünen Halbschmarotzer. Jahrb. f. wiss. Bot. *31*: 77-124. 1897. *32*: 398-452. 1898.

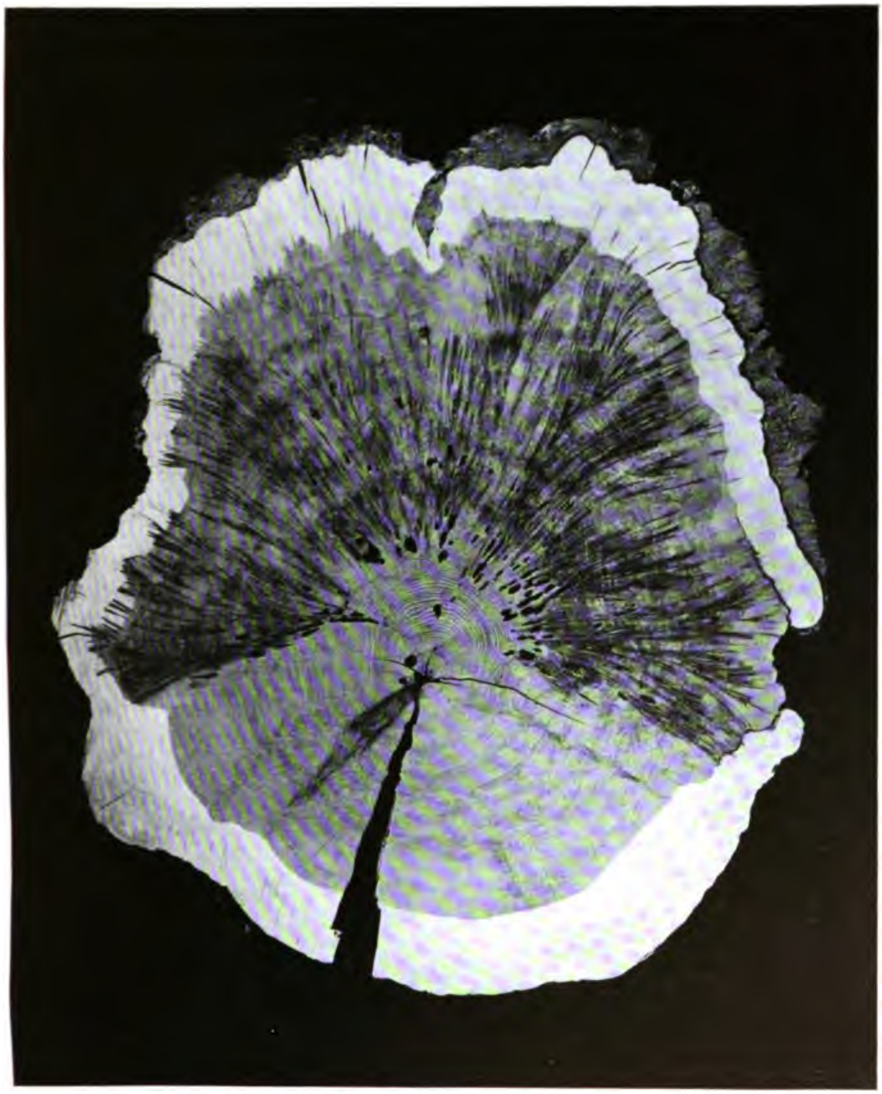

Plate I.—Cross-section through swelling of the trunk of an Incense Cedar, showing the distribution of the sinkers of *Phoradendron juniperinum libocedri.* The holes toward the center are caused by dry rot (peckiness).

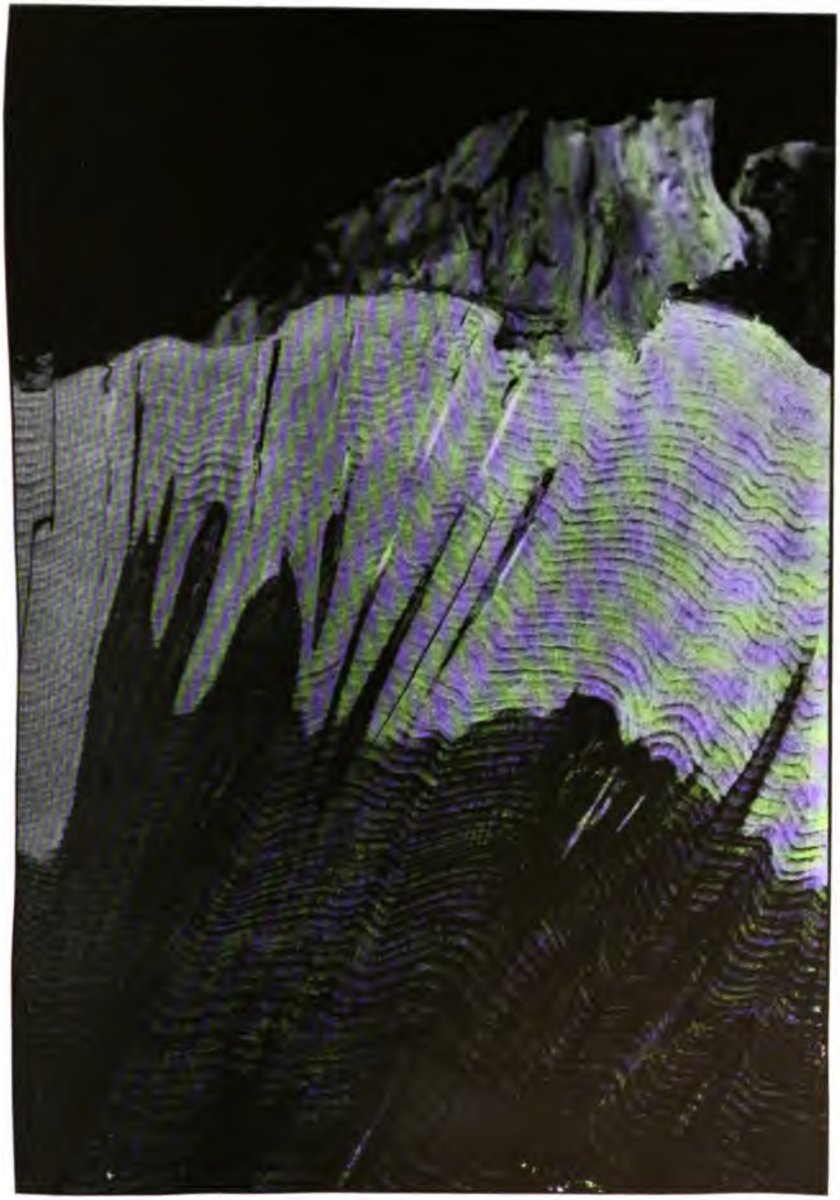

PLATE II.—Detail from plate I. The white sinkers in the sapwood are living.

green shoots suffices, together with the assimilates furnished by the chlorophyll containing surface roots, to keep the mistletoe alive for some time. When the green surface roots also are eliminated by the progress of bark formation in the host the mistletoe dies.

Phoradendron juniperinum libocedri goes one step farther in its parasitism. Normally it also starts as a hemiparasite, assimilating carbon dioxid in the green stems and in the green surface roots. The enormous development of bark in incense cedar in the course of time eliminates both the green shoots and the surface roots; the plant then becomes purely parasitic, and consists only of the widely spread root system and numerous adventitious buds, which cannot develop on account of the thickness of the incense cedar bark. As it is hardly probable that this mistletoe acquires the faculty of utilizing organic food from the host at a very much advanced age, we may safely assume that from the very beginning *Phoradendron juniperinum libocedri* normally abstracts organic food from the incense cedar it inhabits, not only water and inorganic salts.

It remains to be shown whether the phlœm of incense cedar has any direct connection with the phlœm of the mistletoe it carries, as is the case with other true phanerogamic parasites; this would furnish the anatomical proof for our deductions. It is of interest to note that while both *Viscum album* and *Phoradendron flavescens,* in spite of their lesser degree of parasitism frequently kill the branches on which they grow, the incense cedar *Phoradendron* lives with its host tree for many years without injuring it seriously, although in later years it takes all its substance from that source.

NATIONAL FOREST SALES ON THE PACIFIC COAST

BY W. B. GREELEY

(Contributed)

The article contributed by Supervisor Kirkland in the September "Quarterly" presents a strong argument by a man directly familiar with the things of which he writes for the immediate cutting of the National Forests of the Pacific Northwest up to an amount which approximates the annual growth. There can be no question of the soundness of many of Mr. Kirkland's conclusions. Chief among these is the rapid deterioration of old stands of Douglas fir. This deterioration is not only reducing the volume of merchantable timber on such areas, but means a loss to the country of the wood which these exceedingly productive forest soils would grow if stocked with young timber. There can be no dispute on the question that good forestry demands the cutting of such overmature stands as soon as possible in order to harvest an overripe crop and utilize the capacity of the land in the production of a new crop.

Nor can there be any question as to the desirability of management for a sustained yield at the maximum annual cut which each unit is capable of maintaining by growth. This is the ultimate and ideal system which the administration of the National holdings should aim to bring about. It means stability in timber supply, stability in the revenue derived from each administrative unit, and stability in the income to the States. It will make possible also stability in the size and organization of the force on each Forest and stability in the local lumbering industry which is built up upon it. Ideally speaking, we should reach this system of management on each National Forest as quickly as possible, and thereafter adhere to it without variation.

Certain limitations upon the application of this policy, however, exist. These limitations are partly physical and partly involved in other features of public policy which to a greater or less degree conflict with the plan of management advocated by Mr. Kirkland. It may be of interest to indicate the more important of these briefly as comprising, in the judgment of the writer, the *granum salis* with which Supervisor Kirkland's argument should be taken.

The first and controlling factor is the physical limitation upon National Forest sales imposed by the inaccessibility of a large portion of our

stumpage. Fully 75 per cent of the Government timber must await the slow development of transportation facilities before it can be placed upon the market. Closely allied with this physical obstacle is the economic limitation imposed by competition with private timber. In every locality where the larger bodies of National Forest stumpage exist extensive tracts of privately owned timber are also awaiting exploitation. Private stumpage is not only as a rule more accessible than that owned by the Government, but is of somewhat higher quality, since it was selected as the cream of the timbered domain before restrictions were placed upon the acquisition of public lands. The private tracts represent investments for land and timber and carrying charges for interest and taxes. These necessary evils of private ownership are almost invariably factors tending to force the exploitation of such stumpage. In many instances they are urgent factors. It is almost axiomatic that a stable demand for National Forest stumpage, essential to support a sustained yield management, cannot exist until the competing bodies of privately owned timber have been reduced to a point as yet reached in comparatively few portions of the West.

The influence of inaccessibility and competition with private timber in restricting the bare possibility of National Forest sales is shown by the ratio of our present business to the annual cut which the Forests would support. During the past year the annual cut which the National Forests were estimated to be able to sustain permanently totaled 3,274,000,000 board feet. The actual cut under both timber sales and free use permits was 498,000,000 board feet, but little over 15 per cent of the actual yield of the Forests. On the National Forests on the west slope of the Cascades in Washington and Oregon, the specific region under discussion, the actual cut was 32,056,000 feet out of a possible cut of 553,000,000 feet, but 5.8 per cent of the yield. In this particular region inaccessibility and competition with private timber have kept the annual cut at the lowest percentage of the yield obtaining anywhere in the United States.

A sustained annual yield presupposes a sustained market. It presupposes the development of transportation facilities at a rate which will make all portions of a Forest progressively accessible within the cutting period in which it is to be worked over. This condition we have reached only in rare instances. Out of 162 National Forests there are scarcely more than a dozen where the fundamental conditions of accessibility and demand have yet made it possible for the Service to sell even a considerable proportion of the annual cut which the Forest would sustain. These essential prerequisites to a sustained yield management will

come about very slowly. Many years must elapse before it will be possible for the Service to apply this principle of administration on any considerable portion of its area.

A third factor operates from the standpoint of public policy to restrict sales and prevent the attainment of the sustained yield ideal. This is temporary depreciation in the lumber market. Under the conditions now prevailing in portions of the West and with special acuteness on the northern Pacific Coast, extensive sales can be made only at a sacrifice in the values at which Government stumpage has hitherto been appraised and which former markets have justified. Current lumber values in the Douglas fir markets of the Northwest have dropped some $3 a thousand feet as compared with those obtained in 1906 and 1907. There is a drop of from $1 to $2 as compared with prices prevailing but little over a year ago. We believe that the current rates represent a temporary, abnormal depreciation below the stable or normal values of manufactured lumber in that district. To make sales in such localities on the current market would mean the adoption of a "bargain day" policy. It would sacrifice the intrinsic value of National Forest stumpage. All of the larger sales made by the Service, the sales which make up by far the greater part of the annual cut, require cutting periods of from three to five years or even longer. A lowering in stumpage rates sufficient to make sales possible in the Douglas fir belt at the present time not only means a sacrifice of part of the intrinsic value of our timber during the period while the present depreciation exists, but it entails the contracting of large amounts of stumpage at rates which within two or three years, or half of the period required in a majority of the larger contracts, will probably be excessively low for the lumber market then existing.

National Forest timber represents a great national security. It is the duty of the Forest Service, as I conceive it, to maintain the value of this security at par. We are acting in the interest of its owners, the people of the United States, whom we represent in the administration of these lands. Our position is not unlike that of the directors of a large commercial enterprise who are responsible to their stockholders for maintaining the securities in which the latter have invested at par value.

An important factor in every such period of depreciation in the Western lumber markets is overproduction. To the extent to which the Service forces sales by reducing stumpage prices during such periods it accentuates overproduction and aids to perpetuate the depreciation in lumber values. It therefore aids to perpetuate the resultant depreciation in the value of the enormous body of public property which National

Forest stumpage represents. Lumber production, furthermore, in such periods is invariably attended by wasteful logging, tendencies to restrict the cut to species and logs of the better grades, and other efforts to maintain the profit per unit of manufactured material. All of those result in the waste of Forest resources. I do not believe it wise policy to force the utilization of National Forest timber under such conditions.

In other words, a third essential of sustained yield management, viz: stable lumber values, is also lacking. A sustained yield presupposes stable market conditions which maintain consistent values for raw Forest products. Practical business considerations demand the reservation of timber from exploitation when such values are destroyed by overproduction. They forbid the throwing of timber upon a broken market in order to maintain a theoretical ideal of Forest management.

All of these conditions unite to postpone for many years the time when the sustained yield management of National Forests on a general scale will be practicable. From the standpoint of delaying the cutting of overripe timber and the full use of the protective capacity of forest land this is bad. Viewed from another angle, it may not be a public misfortune. It is generally conceded that at the rate of consumption prevailing during the last decade another generation will witness the practical exhaustion of the virgin timber supply of the United States. It is reasonable to believe that a critical economic period as regards the production and use of lumber will attend this exhaustion. In that period it will be necessary for both the production of lumber and its per capita consumption to adjust themselves to the cost of *producing and harvesting stumpage.* The cost of harvesting virgin supplies will no longer be the primary factor. A large national timber reserve will be of inestimable value in tiding the country over such a period. If the bulk of the virgin stands on the National Forests are held until that time they can then be utilized to meet a critical need rather than wastefully cut, and thrown upon a market already glutted with private timber. Aside from the far greater benefit which the country as a whole would derive from such stands at that time than at the present, the immediate financial interest of the people in these common holdings would be enhanced by the much higher values obtainable and the much closer utilization which would be secured.

From the point of view of Mr. Kirkland, it might be claimed that the same crisis could be most effectively met by the Government's putting its own lands as rapidly as possible in a condition where their production of wood will be the maximum possible under scientific management. The Government would thus make its own lands produce the greatest

future supply of which they are capable. It would also definitely point out to private owners the course to be taken on their lands in adapting their industry to the new economic conditions. There is a deal of justification for this method of meeting the problem. It is, of course, the ultimate one. With a critical timber famine in view some thirty years hence, however, it must be borne in mind that the new crops grown on lands now cut over would not be available at the time of serious need. In the Douglas fir belt itself, where the production of second-growth timber is probably the most rapid in the entire country, eighty years is now taken as the minimum rotation to be applied to second-growth stands. Particularly since, as pointed out in Mr. Kirkland's article, these stands must be cut clean and reproduced from the bottom, the second crop will not be available when the country is hungry for timber. In spite of the loss in mature fir from deterioration, the country as a whole may be benefited more by reserving a considerable portion of these stands against the time of critical need than by cutting them off too rapidly, under present market conditions, in order to put the growing power of the soil to work.

As a practical question of administration, it is neither possible nor desirable to go to either extreme. Large sales must be made on certain Forests to support mining and other local consumption. Additional sales in localities where transportation facilities and competition with private stumpage permit, and where stable values can be maintained, are desirable to place the National Forests upon a basis of self-support. This will be accomplished if the actual cut can be brought up to one-half of the yield. It may be desirable to do no more than this, leaving the remainder to accumulate as a reserve supply. It is almost certain that no greater proportion can be sold during the next five or ten years under the limitations imposed by inaccessibility, private competition, and the necessity for maintaining stable values.

To dispose of even half of its possible cut the Service must depart from the practice of a sustained annual yield by administrative units. Unequal distribution of transportation facilities and good markets necessitates an unequal distribution of the yearly cut. Our sales must to a greater or less extent be concentrated in localities where Forest stumpage has been made accessible and where the market is ready for it. While provision should always be made for the permanent local consumption in the territory dependent upon each National Forest, it will be necessary in some cases to exceed the sustained cut of an individual unit. The excess will apply to that part of the timber which can be consumed only in the general markets of the country.

Aside from administrative interests in the matter of revenue, this course is justified, since the boundaries adopted for convenience in the management of the Forests seldom coincide with the limits of economic units within which the marketing of timber is controlled by certain factors of consumption or distribution. Two illustrations may make this plain. The Whitman, Ochoco, Umatilla, and Malheur National Forests of Oregon form jointly a compact economic unit. Aside from the insignificant amount required for local consumption, their timber must, within the range of human foresight, be marketed to the southeast over the main and feeder lines of the Oregon Shortline Railroad. With over 90 per cent of their cut passing through a common railroad point, these four administrative units are economically one unit. If a sustained yield from the entire market unit is maintained little injury, certainly to the broader public and industrial interests served by the National Forests, is conceivable if the stand on one or more of the administrative subdivisions is overcut.

A second instance is found in the Forests of south-central Montana tributary to the Butte Copper Mining district. Three Forests, the Helena, Deerlodge, and Beaverhead, are tributary by topography and railroad development to one great consuming market—the copper mines. No other outlet for the great majority of their stumpage can be foreseen. Conversely, the mines must rely upon these units for the greater portion of their permanent timber supply. A distinct economic unit is thus created by a distinct consuming point, from the standpoint of both market and stumpage. The progressive working over of these Forests to supply the annual consumption of mining timbers may disregard administrative boundaries without injury. Cuts in excess of the sustained yield from any one of these Forests will be of little moment as long as the yield from the entire unit is maintained.

As a matter of fact, modern conditions governing the distribution and sale of lumber make a sustained yield from the standpoint of a permanent supply for consumers of wood very much of a fiction. Geographical considerations are often wholly counterbalanced by relative cost of production and distribution under competitive freight rates. Even in the two concrete cases cited the limits of the economic units are not clear. The Forests on the Snake River drainage in Idaho supply the same market over the same railroad system as the group in northeastern Oregon. Timber sold from the latter is shipped past the doors of the Idaho Forests, shutting their own supplies out of the market. While the bulk of the supply for the Butte mines is cut from the Deerlodge and we regard that Forest, with its neighbors, the Helena and Beaver-

head, as furnishing the natural supply for this market, small shipments are made of timbers cut from lands on or adjoining at least three other more distant Forests. There is a series of widening circles around every consuming point, following the lines of least resistance in the matter of cost of production and cheap transportation, which may upset any administrative scheme of permanent timber supply based upon the geographical location of stumpage. Even the fetish of "local needs," which has swayed many a council of Service "braves," yields to the aggressive market expansion of these latter days. I was strongly impressed by this fact two years ago. I found several little operators supplying communities in the northern Rocky Mountains, communities with the most meager railroad facilities, forced out of business by shipments of fir lumber from Puget Sound. The cheaper production of the larger operation and its aggressive search for markets had overcome a matter of 700 or 800 miles, and run the lodgepole and fir of the northern Rockies out of a market adjoining their mill yards. "Local needs" has come, in my mind, to signify only the consumption of timber in localities beyond the range of railroad distribution.

These are some of the conditions which, from the standpoint of public supply, make strict adherence to a sustained yield by Forest units unnecessary. The Service must take advantage of these conditions by concentrating sales in districts where they are possible at desirable terms. Otherwise it cannot dispose of any considerable proportion of the aggregate annual yield of the Forests. Let me emphasize again that this is not the best or the ultimate scheme of administration. It is imposed upon us by the practical exigencies of the situation. From the standpoint of the executive officer it has obvious disadvantages. In so far as it is applied, it makes for instability in local organization and in revenue from administrative units from period to period. To some extent it threatens the stability of the lumbering industry, viewed through a long term of years, which is built up upon certain of the Forests. It should be temporary in duration. As transportation facilities are developed and the demand for Forest timber becomes more general, it will cease to be necessary. These factors, combined with more stable market conditions, will in time make it possible to distribute the cut much more evenly over all the Forests. A sustained yield management can then be realized.

The plan of cutting advocated by Mr. Kirkland, clean stripping followed by artificial regeneration, is undoubtedly sound silviculture. The inclusion of clauses in sale contracts, however, under which the purchaser would contribute to the cost of reforestation by furnishing labor

or otherwise, is not possible. This throws the whole burden of seeding or planting sale areas upon the Forest Service. It may be questionable, therefore, whether this method of cutting can be applied as generally as strictly silvicultural considerations would require.

An enormous area of denuded lands within the National Forests, aggregating some 7,500,000 acres, is awaiting artificial reforestation. The idleness of this land as a possible producer of wood is the greatest source of loss in the administration of the National Forests from the standpoint of either revenue or future timber supply. With this great task of reforestation confronting the Service on lands where tree growth cannot be secured by any other means, it is doubtful in my judgment if we would be justified in drawing upon our limited resources to any extent for the reforestation of lands from which the virgin timber has been removed under our own contracts in such a manner as to make artificial stocking necessary.

Certainly the adoption of this method, in view of the major reforestation problem, would be warranted only on a limited scale and in the most urgent cases. Natural regeneration should be secured wherever possible, even at a sacrifice of the best silviculture from the standpoint of the cost of establishing the new crop. In its practical application, this may require the restriction of artificial restocking to very decadent stands in which the Douglas fir is exceptionally old, large, and of questionable seed-bearing capacity or from which it may have largely disappeared. In the less decadent stands, up to an approximate age of 250 years, we may have to resort to natural regeneration under some system of clear cutting with seed trees. It is apparent that large areas of second-growth Douglas fir have been established by this method, through the selective nature of most of the early cuttings combined with fires in the slashings. It appears feasible to work out an adaptation of this system by the selection of either defective trees having little merchantable value, as suggested by Mr. Kirkland, or seed trees grouped with reference to windfirmness and seed distribution.

This method may entail an investment in uncut stumpage of two or three times the cost of artificial reforestation. Aside from the practical consideration that this investment costs the Service nothing, whereas the investment in artificial reforestation is a direct drain upon a meager appropriation, there is a broader point of view of the question. Our immediate duty in the silvicultural administration of the Forests is to bring the annual production of timber up to the maximum of which the soil is capable. This applies both to the cutting of merchantable timber and to the planting of areas from which all forest growth has been

removed by fire. Both enter vitally into the general problem of increased wood production. Even a material financial sacrifice as between natural and artificial methods of reforestation may be justified if the dollars otherwise spent upon the replanting of sale areas can be used to reforest an equal acreage of land which is now absolutely idle. The controlling point of view must be, in my judgment, the sum total of results in increasing the actual production of timber on the National Forests.

THE RELATION OF SOIL ACIDITY TO PLANT SOCIETIES

BY ARTHUR WM. SAMPSON

(Contributed)

It is a matter of common observation with the field botanist that different soils support different plants. The economic significance of the grouping together of vegetation into characteristic societies and communities, with respect to the acidity and alkalinity of the soils, was first brought to my attention in a study of the vegetation and conditions in the Wallowa Mountains in northeastern Oregon. In this region a line of investigation was initiated by the Forest Service, which was suggested by Mr. Frederick V. Coville, Botanist of the Bureau of Plant Industry, for the purpose of determining which cultivated or introduced forage species are best adapted to restore the productiveness of depleted grazing lands.

One of the means by which certain of our depleted grazing lands may be restored to their former carrying capacity is by reseeding them to suitable cultivated forage plants. It appears, however, that the soil preferences of some of the most promising cultivated species are such that in the judicious reseeding of the range an intelligent study of soil chemistry is of high importance. As a concrete example, white clover (*Trifolium repens*), a valuable forage plant in many localities, is, like a great many other Leguminosæ, extremely sensitive to acid or sour soils. Both under field conditions and in the laboratory it is found that this plant grows under protest, as it were, in soils rather weakly acid. In soils requiring for neutralization the relatively small amount locally of 5,000 pounds of lime per acre foot, that is, to a depth of one foot, this species fails. Laboratory tests have revealed that white clover and other related species fail to develop the bacterial nodules in soils of relatively low lime requirements. On the other hand, some forage species, notably redtop (*Agrostis alba*), as evinced by the luxuriant growth made, prefer sour soils.

As shown, then, it is evident that in connection with the reseeding work a study of the native plant societies as indicators of acidity, alkalinity, and neutrality of the soil is imperative. Certain societies seem to be confined very definitely to particular isolated localities and are

quite absent from many closely adjacent lands where the physical structure of the soil, the conditions of exposure, extremes in temperature, and the amount of precipitation are very similar. Some species, however, show no apparent selection for soils so far as their chemistry is concerned, but grow equally abundantly and luxuriantly on both acid and alkaline lands.

During the seasons 1910 and 1911 about a hundred soil samples were taken in a great many habitats in the attempt to ascertain the relationship between the acidity or alkalinity of the soil, whichever the case might be, and the character of the vegetation growing upon it. I am greatly indebted to Mr. Breazeale and Mr. Baston, of the Bureau of Chemistry, for the making of a great many of the soil acidity analyses.

In general, strongly acid habitats are characterized by a superabundant supply of moisture coupled with poor drainage. Such lands usually support a dense stand of vegetation which often produces a matter surface and an entanglement of long root-stocks which bind the soil firmly. The species occur both socially and in admixtures. *Carex* is the most common social species, and societies of *Carex-Juncus, Ranunculus-Phleum,* and *Elephantella-Dodocatheon* are very commonly met with. The soils in these situations require for neutrality from about 8,000 to 16,500 pounds of lime per acre foot, or from 4,000 to 13,000 pounds for the production of a clover crop.

In the beginning of this study it was presumed that the lighter soils—those with an intricate mass of interwoven roots, and having an air-dry weight of 15 to 30 pounds per cubic foot—were the more acid. Later it was found that the sourest soils are those of the well-drained lands which support the mountain bunchgrass (*Festuca viridula*) society. This species appears to vary more widely than any in adaptability to acidity. The soils upon which it grows luxuriantly vary in lime requirements from 5,000 pounds, as a minimum, to 41,000 pounds as a maximum. These soils have an average weight of 70.5 pounds per cubic foot. The heaviest soils tested weighed 82, 78, 77, and 74 pounds per cubic foot, respectively. The two intermediate ones are very slightly acid, while the heaviest and the lightest of these are alkaline.

An attempt was made to correlate depth of soil with its weight and acidity. For this purpose a typical location was selected in the midst of a luxuriant society of mountain bunchgrass. A hole six feet in depth was dug and samples at definite intervals were analyzed for acidity and the weight per unit volume of soil determined.

Sample I represents the soil from 1 to 12 inches in depth; Sample II, from 12 to 24 inches, and so on up to Sample VI, inclusive. The

weights of the soils per cubic foot from the surface downward are 67, 68.5, 70.5, 74, 78.5, and 83 pounds, respectively. The lime requirements per acre foot from the surface down are, respectively, 32,000 pounds, 29,000, 8,000, 5,000, 3,500, and the lowest sample representing the soil from five to six feet in depth, is neutral. There seems to be no *necessary* connection between weight and acidity of the soil when the various types are considered, an impression which the last cases cited might seem to convey; for example, the seventh heaviest of the many samples collected on the Wallowa Forest proved to be, with one exception, the most acid of all. However, of the 13 samples which gave a neutral or alkaline reaction, all but one were above the average in weight. The reason for this relation between soil weight and acidity, where it exists, is no doubt to be found in the presence or absence of humus, which, on the one hand, is responsible chiefly for the acids of the soil, and, on the other hand, its lightness necessarily affects the weight of the soil.

A brief résumé of the acid endurance and requirements of the various local conspicuous plant societies is here given. They are arranged in accordance with the degree of acidity of the substratum. In this list the mountain bunchgrass society easily leads.

1. *Festuca viridula* society.
2. *Carex* society.
3. *Alnus-Salix* society.
4. *Veratrum-Redbeckia-Mertensia-Valeriana* society.
5. *Phleum-Elephantella-Dodocatheon* society.
6. *Vaccinium-Phyllodoca* society.
7. *Deschampsia-Juncoides* society.
8. *Pinus-Calamagrostis* society.
9. *Pinus-Abies-Polemonium* society.
10. *Panicularia-Cinna* society.

1. The mountain bunchgrass society occurs conspicuously throughout the extensive high, well-drained meadows and bald buttes on the characteristic basaltic clay loam soils. It occupies more acreage than any other society of the Hudsonian zone. Commonly but usually inconspicuously associated with mountain bunchgrass may be mentioned: *Stipa minor, S. occidentalis, Sitanion velutinum, Melica bells, M. spectabilis, Logusticum oreganum,* and *Polygonum phytolaccæfolium.* The soils of the various habitats vary in lime requirements for neutrality from about 3,000 to 41,000 pounds.

2. The *Carex* society typically is rather hydrophytic than mesophytic in character. The soil has a definite humidity of from about

50 to 80 per cent; it is always deep and rich in humus. The vegetation is continuous and compact, and forms a dense tangle of roots and rhizomes. The wet, poorly-drained meadows are usually occupied by this society. The most common species are *Carex vulgaris, C. tolmei, C. festiva, C. illota,* and *C. exsiccata.* The lime requirement of the soil varies from approximately 4,000 to 16,000 pounds.

3. *Alnus-Salix* society. This society occurs along mountain streams, in swales of various kinds, in soils of high humidity and rich in decayed vegetable matter. Of the herbaceous species *Claytonia* and *Mertensia* are usually associated with it. The lime requirement of the soil is between 11,000 and 15,000 pounds.

4. The *Veratrum-Rudbeckia-Mertensia-Valeriana* society usually occupies the drier outer border of the hydrophytic *Carex* society. *Veratrum viride* and *Rudbeckia occidentalis* are the most conspicuous species. The soil requires for neutrality between 9,000 and 14,000 pounds of lime.

5. As evinced by the frequent intermixing of the *Phleum-Elephantella-Dodecatheon* society, this, the fifth group, with the *Carex* society, has about the same requirements as the hydrophysic *Carices.* Except for *Phleum alpinum*, members of this society never occur socially. In general, however, the species concerned occupy soils of less acidity, the lime requirements varying from about 9,000 to 11,000 pounds.

6. The *Vaccinium-Phyllodoce* society is one of those that apparently never occurs in neutral soils. It appears to be a sure indicator of acidity. *Vaccinium scoparium* and *Phyllodoce impetriformis* are the species concerned. They are usually confined to the partly sheltered soils of the Hudsonian zone, and extend to timber line. The lime requirements of the soil are between about 3,000 and 11,000 pounds.

In this connection it should be stated that the blue huckleberry (*Vaccinium membranaceum*), which occurs at lower elevation than *V. scoparium*, has nearly the same lime requirements as the latter.

7. The *Deschampsia-Juncoides* society occupies moist, well-drained meadows, too dry for hydrophytes. The species concerned are *Deschampsia cæspitosa, D. atropurpurea, Juncoides glabratum,* and *J. parvifolium.* The lime requirement of the soil is about 11,000 pounds.

8. The *Pinus-Calamagrostis* society occurs in the transition zone. It is characterized by *Pinus ponderosa* and *Calamagrostis suksdorfii.* Here the fallen fragments accumulate year after year and produce a large amount of humus. A wide variability is found in the lime requirements of the soil. To the depth of the grass roots the soil is always acid and usually the acidity extends much deeper. From 2,000 to 11,000 pounds of lime per acre foot are required for neutrality.

9. The *Pinus-Abies-Polemonium* society is restricted to the dense tree clumps of the Hudsonian zone. *Pinus albicaulis, Abies lasiocarpa,* and *Polemonium humile* are the species concerned. The soil is especially rich in humus and requires between 5,000 and 10,000 pounds of lime per acre.

10. The *Panicularia-Cinna* society is hydrophytic, the species *Panicularia nervata* and *Cinna latifolia* growing in staurated soils. These grasses are cæspitose, but reach a good height growth and are rather conspicuous. Their soil requirements for neutrality range between 2,000 and 5,000 pounds of lime per acre.

The genera making up these associations are almost invariably confined to the sour soils. Some species, however, seem to show no particular preference for acid lands, or at least they seem to grow equally abundantly on both sour, neutral, and alkaline soils.

Locally the most common genera that inhabit the calcareous rock formations are: *Pteridium, Aquilegia, Achillea, Pentstemon, Lupinus, Erigeron, Agropyron, Elymus, Sitanion, Stipa, Berberis, Artemisia,* and *Populus.* Of these it is definitely known that *Pteridium, Lupinus, Stipa,* and *Populus* occur also on somewhat sour soils.

During the past season it was my pleasure to make a reconnaissance study of the vegetation on the Manti National Forest in central Utah. The rock formation there is mainly limestone and sandstone, with the former predominating.

Unfortunately the season was so far advanced at the time this Forest was visited that a satisfactory plant collection could not be made. However, through the kindness of Mr. Ivar Tidestrom, of the Bureau of Plant Industry, much additional information on the soil preferences of the vegetation was obtained.

The genera commonly occurring on the calcareous soils are:

Gilia.
Solidago.
Monolepis.
Eriogonum.
Castilleja.
Erigeron.
Pentstemon.
Bromus (2 species).
Poa (4 species).
Agropyron (2 species).
Elymus.
Artemisia.
Pachystima.
Berberis.
Peraphyllum.
Opuloster.
Picea parryana.

In the sandstone soils, which are acid in character, the following genera make up the main vegetation:

Agosteris.	*Aragalus.*	*Sambucus.*
Epilobium.	*Sodum.*	*Arctostophylos.*
Veronica.	*Valeriana.*	*Juncus.*
Equisetum.	*Rudbeckia.*	*Carex.*
Delphinium.	*Ligusticum.*	*Pseudotsuga.*
Mimulus.	*Vagnera.*	*Abies.*
Geranium.	*Agrostis.*	*Picea.*
Draba.	*Calamagrostis.*	*Pinus.*
Arnica.	*Elymus.*	*Salix.*
Dodecatheon.	*Stipa.*	*Betula.*
Aconitum.	*Sorbus.*	*Alnus.*

The genera that are apparently indifferent to either of these soil types—*i. e.*, occur on both acid and alkaline lands—are:

Monolepis.	*Rosa.*
Frasera.	*Gragaria.*
Lomatium.	*Aquilegia.*
Solidago.	*Amalanchier.*
Gilia.	*Abies* (2 species).
Thalictrum.	*Pinus edulis.*
Pentstemon.	*Populus.*

There are others of less importance.

It is highly interesting to learn that about 80 per cent of the genera occurring on the lower basaltic clay loam soils and on the calcareous soils in Wallowa Mountains are also found in the sandstone and in the limy soils of central Utah. Among the genera that occur on both acid and alkaline lands some make a luxuriant growth on the one type, but do not develop normally on the other. The conifers, for example, notably *Pinus ponderosa,* are scattered and uncharacteristic locally and usually dwarfed on the limestone soils, while they grow luxuriantly on the sandstone lands. On the other hand, Engelmann spruce probably grows most luxuriantly on the calcareous soils.

From detailed studies made by Mr. Frederick V. Coville, as well as by several European botanists, on the soil preferences of plants, it appears that the *Ericaceous* species generally are more closely confined to acid soils than those of any other family. Mr. Coville has found that both in this country and in Europe native species of *Vaccinium* invariably inhabit sour soils. Through a series of potting experiments Mr. Coville

learned that the blueberry cannot be grown successfully in alkaline or sweet soils.

During the past two seasons I have examined a great many soils from *Vaccinium* habitats and have found all of them at least moderately acid.

It was learned last November that the huckleberry or blueberry in the vicinity of Williamstown, Mass., grows luxuriantly on the limestone soils there. With this understanding I was called upon to investigate the conditions in that locality. The lithographical character of this country has been recorded by the U. S. Geological Survey.

Almost invariably the common huckleberry there, *V. pennsylvanicum*, is confined to the granite, gneissic, and schistose mountains. A few plants, however, were found on the limestone formation in association with white pine and oaks. Upon examination, however, it was learned that the roots were extremely superficial and only extended to the leaf-mould litter. Samples of the substratum were taken and found to be very acid to a depth of the root system. At greater depth the soil was strongly alkaline.

Ever since the days of Unger and Thurmann there has been considerable difference of opinion in the relationship between soil chemistry and the vegetation. European botanists have listed a number of plants which are said to avoid calcareous soils. On the other hand, the physical theory, as Warming has shown, is favored by the influence of soil water and consequently by the physical structure of the soil. The grouping together of plants into societies doubtless depends both upon the physical and chemical condition of the substratum. In the localities studied, however, the physical texture and the water content seem to be of secondary importance.

TIMBER BONDS

BY EDWARD A. BRANIFF

(Contributed)

I

General Features of Timber Bonds—Growth of the Timber Bond Business

Within the past few years there has come into increasing prominence in the West and South a class of securities based upon growing timber, commonly called stumpage, the bonds thus issued being known as timber bonds. Technically they are industrials, but for reasons that will soon be apparent they are generally regarded as being in a class by themselves. Certain bond houses in Chicago, St. Louis, and Detroit make a specialty of them, and a few have standardized their requirements to a high degree. These houses employ experts who understand the nature of the security and the steps necessary to safeguard their issues. They have been quite successful in finding a market for their wares. Especially among retired lumbermen and others familiar with the various phases of the logging and lumber business is there a market for timber bonds, since such men are able to exercise discrimination in the selection of their purchases. The nature of these timber bonds makes them also very desirable for investments by Western banks and banking institutions, who purchase them as they would purchase short-term notes and commercial paper. This latter demand has shown such considerable growth of late that the market for timber bonds has much improved.

These bonds are much better known in the West than in the East. Although a few issues of Eastern concerns, particularly of paper and pulp mills, have been sold in the East, they have constituted but a very small proportion of Eastern bond investments. Most Eastern houses are even now totally ignorant of what constitutes a good timber bond. The Western bond houses which specialize in these issues are much better informed and their standard of requirements is, as a rule, quite high. It is inevitable that appreciation of the high merits of timber bonds for

certain classes of investors will soon obtain in the East, with a consequent growth in demand for these securities.

The subject gains much in interest from the fact that timber bonds in their present form represent probably only a first phase in their progression, and that securities based upon stumpage will likely play an important rôle in the conservation movement in this country. In the performance of this service it is not improbable that their character will change radically in certain respects. For instance, it seems that when such issues are based upon forests managed under a system that insures a second cutting, or perhaps a sustained yield, the securities, instead of maturing at uncertain intervals, none of which is more than 15 to 20 years from date of issue, will have a much longer life. Also, whenever it becomes feasible for private owners of timber in this country so to manage their timber, their securities will sell at a higher price than they now do and their yield will be less.

Bonds secured by standing timber are of recent issue; consequently we have not yet been able to test adequately the strength of this form of security. The first bonds of this character were issued about 10 or 12 years ago, though it has only been in the last 7 or 8 years that they have been sold in considerable quantity. So far their record has been exceedingly good. Although a few of the earlier issues have defaulted and it has been necessary for the buyers to take over the properties and pay out the bonds, the writer knows of no instance where any timber bond issue offered by the few responsible houses in the West who specialize in these securities which has failed to meet its obligations. One leading Chicago house which devotes its entire attention to these securities claims to have sold in nine years more than $50,000,000 worth of timber bonds without a single instance of failure to meet interest or principal.

It is also worthy of notice that the volume of timber bonds has greatly increased during periods of business depression, when only the best bonds find a market, and that timber bonds in such times have been in great demand. The past few years have been hard ones for the lumbermen, and the timber bond business has grown by leaps and bounds. "The best bonds are those secured by a permanent monopoly," as a financial writer states, and the ownership of timber is fast approaching a permanent monopoly. "One should buy only bonds of property which will sell in hard times for the amount of the bond," says another financial authority. There is no question that timber bonds issued at the conservative mortgage rate which usually prevails are sufficiently protected even in times of panic.

From the point of view of the bond house these securities are desirable merchandise. The house which takes measures to acquaint itself thoroughly with timber bonds by employing experts to pass upon the physical value of the timber and mill properties, and attorneys to report upon the titles, is able to safeguard these issues to a high degree and offer a safe form of investment, paying a high rate of interest.

From the point of view of the investor timber bonds are in most respects decidedly attractive. The security is probably equal to that of any other class of industrial bonds, and the yield is usually 6 per cent in addition to the premium which is paid when the bonds are redeemed before maturity, as most of the best issues are. This premium varies from 101½ to 110, or even higher. The issues mature in series, the longest of which is seldom more than 30 years from date of issue, and the shortest about 10 years. The first of the series is generally due six months to two years from date of issue, and the other series follow at six-month intervals. Since almost without exception the bonds are optional, and since this optional feature is freely used, the best timber bond issues are seldom allowed to mature, and the life of these bonds is far less than their maturities would indicate. In fact, the best issues, at the rate they have been retired in the past, will run only from 8 to 12 years. No one who holds a timber bond can be sure of when his bond may be called. From one point of view this is an extremely desirable feature, of course, and appeals to a certain class of investors on account of the high premium that is paid for such called bonds, it being possible to obtain on some of the best issues premiums of 110—that is, $1,100 will be paid for called bonds which were sold for $1,000 or less. Disadvantages, however, from the point of view of the conservative investor also exist, as will be later shown.

Denominations of timber bonds are invariably $500 and $1,000, except in a few issues of a speculative nature where a bonus of common stock is offered, in which cases denominations of $100 are also offered.

The investor has the advantage of a good demand from Western banks for the best issues. In numerous instances issues of local lumber companies are actively traded in at the local boards of trade and command a premium.

The largest timber bond issue that has yet been made is $9,000,000. All the bonds were sold within a short time after issue. A Canadian issue recently made was for $6,000,000. The latter was, it is understood, sold largely in the London market at a price to yield about 5½ per cent.

II

The Security for Timber Bonds

Timber lands, like other industrials, demand a larger margin of safety than public service or railroad bonds. The main reason is that industrial earnings fluctuate widely, so that while in good times the corporation may earn many times its bond interest, times of depression will not infrequently cause this margin to fall perilously low. Railroads, on the other hand, and such public service corporations as traction, water, gas, and electric light companies do not experience violent fluctuations in earnings. In the depression of the nineties earnings of the leading industrial corporations shrank about 17 per cent, while railroad earnings fell off only 12 per cent. Following the panic of 1907 industrial earnings fell off about 17 per cent, while railroad gross earnings declined but 7 per cent. "In the decline of 1893, 14 leading industrial stocks fell nearly 50 per cent in price against 40 per cent for 60 railroads. In the decline of 1903, 12 leading industrials fell 46 per cent as compared with 28 per cent for the railroads. In 1907 the industrials fell off 48 per cent in comparison with but 37 per cent for the railroads." *

In the case of railroad bonds, experience with them has extended over so long a period of time that we are able to determine with approximate exactness the margin of safety for their bond issues, and the same is true of several forms of public service corporation bonds. And yet, as Babson says, there are many industrial corporations whose bonds in case of trouble would fare much better than the bonds of public service companies which now sell at higher prices.

Timber bonds share to a certain extent with other industrials this disadvantage of fluctuating earnings. In good times the profits made by a large mill, sawing a high class of timber under favoring logging and milling conditions, are probably as high in proportion as those of any other stable industry in this country. On the other hand, a long period of business decline, when building lessens and railroads stop buying, operates heavily against the lumber business.

Two representative examples of how broadly earnings of lumber companies fluctuate are given below. A very large lumber concern, operating in Louisiana and sawing longleaf pine, showed net earnings in 1906 of $2,330,488, and in 1907 of $2,034,492. The panic of the fall of 1907 hit the business hard, which in 1908 showed profits of only $948,472, a de-

* Moody's Magazine, Vol. XII, No. 4, p. 234.

cline of over 53 per cent from the previous year. Although profits increased slightly in 1909, they have not yet reached the high level prior to the panic.

A long established Canadian concern experienced in 1908 a decline of 43 per cent in its net earnings.

On the other hand, the earnings of a conservatively bonded timber property are always ample to pay interest charges and maturing issues even in dull times. Consider the wide margin of profits of a Texas concern sawing longleaf pine, even in the hard years since 1907. The figures are as follows:

Year	Cost per M feet	Selling price
1908	$6.75	$11.55
1909	6.17	12.17
1910	6 36	12.83

This concern was in an enviable position because of the cost of its stumpage and very favorable milling conditions. It was bonded for $375,000, and its net earnings in the past five years have averaged over $97,000 per year.

An Eastern pulp and paper company showed net earnings in 1909 of over four times its bond interest. An Idaho concern claims to earn, even in dull times, $12.50 per M feet on its white pine and $6.50 on its western yellow pine. A California lumber concern sawing western yellow pine and sugar pine is bonded for $1,200,000. It has made net profits in the past seven years of about $2,500,000. During 1911, which has been an exceedingly bad year for the lumber business, this concern made net profits of about $24,000 every month and paid out in cash dividends $19,500 per month, representing about 12 per cent on the entire capitalization. A maximum amount had previously been charged off for depreciation and maintenance, and the required $2.50 per M had been paid into the sinking fund.

The condition of the lumber business is perhaps most accurately gauged by the condition of the railroads, so that a scrutiny of railroad reports will determine how lumber is faring. Railroads as a class are among the greatest consumers of lumber in this country.

One of the most serious problems which concerns a sawmill is the disposal of its low-grade material. As the forests are cut off, the first timber to be removed is the large trees, which yield most of the good grades. High grade lumber is, relatively, always easy to dispose of and suffers

least in price depression. But as the proportion of low grades is constantly increasing the problem of their disposal becomes pressing. The cessation of railroad buying is, therefore, in itself always a heavy blow to the lumber business. Also when railroads stop buying it is generally true that demand from other sources is very slack. The low grades thus pile up in the yards at an alarming rate. It is not unusual on the Pacific coast under such circumstances for Oregon fir dimension prices to drop 40 to 50 per cent in a few months. Such conditions prevail also in southern pine, in western cedar, in hemlock, and other woods where the development of the timber areas has been especially rapid during prosperous times. They do not obtain to so marked a degree with timbers that exist in very limited amount and are in the hands of strong corporations, such as western white pine, cypress, yellow poplar, and eastern white pine.

Although the lumber business is susceptible to these price fluctuations, yet the industry as a whole possesses great stability. Those concerns which are operating with a management of even ordinary ability and have today large holdings of timber behind the mill plant, secured under prices prevailing 5 to 10 years ago, are in an enviable position. Their securities should, other things being equal, possess great strength.

Timber bonds seem to possess unusual advantages over most forms of industrials. The security is one of our natural resources which is fast dwindling and fast falling into a comparatively few hands, while the demand for it is fast increasing. Timber bonds are thus secured by what approaches a natural monopoly. They are much less dependent on earnings than most industrials, since only a relatively small part of the equity behind them lies in the manufacturing plant. While railroads and most forms of public service corporations have about reached the limit of their bonded indebtedness, lumber companies have only just begun to issue bonds on their properties. Consequently much better bargains may be secured in such issues, provided care and discrimination is used in their selection.

It should be remembered that where an honest appraisal is made by competent men there can be little chance for serious error in fixing the amount and value of a tract of timber. Timber is all above ground, where it can be seen and measured. Again, timber possesses the advantage of growth, and (a fact seldom recognized) as a tree grows larger its quality improves, so that the average value of its timber becomes steadily greater. This fact may be shown clearly by the results of a series of experiments conducted by the writer* in a number of sawmills in the

* "Grades and Amount of Lumber," etc., by E. A. Braniff. Bulletin 73, Forest Service.

South and in the Adirondacks of New York. These experiments proved, for example, in the case of yellow poplar, that the average value of the lumber increased $8.81 per thousand feet between a 16-inch and a 30-inch tree. Considering the increase in stumpage price alone and disregarding growth and quality increment, an issue of timber bonds made at the time these experiments were conducted (seven years ago) would have been at the mortgage rate of about $2.50 per thousand feet, the stumpage then being worth about $5 per M feet. Since that time this timber has increased to not less than $12.50 per M feet. Thus the actual value of the security, assuming that the bonds were redeemed by a sinking fund proportionately with the removal of timber, would have increased from twice to nearly five times the bonded debt.

Issues of timber bonds rest mainly upon stumpage. While the sawmills, logging equipment, and railroads are always subject to the mortgage, yet it is the timber by which the bond issue is to be judged.* The mortgage rate on timber is generally from 40 to 50 per cent of the appraised value. When it is recalled that real estate mortgages are freely placed at 75 per cent and railroad equipment bonds at 75 to 90 per cent, and that the best timber bonds afford safeguards quite superior to most bonds of the other two classes, the mortgage rate on timber bonds seems extremely conservative. It is so conservative indeed as to discount in large measure the factor of decreased earnings in hard times. The timber behind a good timber bond, irrespective of fluctuating earnings, is readily salable even in hard times for a price far beyond the mortgage rate. Consider, for example, a recent issue of $795,000 of 6 per cent first mortgage serial gold bonds of a concern owning a tract of Douglas fir in western Oregon. This concern, because of the strategic position of its properties in relation to logging, is able to buy logs delivered at its mill at $5 per M feet as against $7 to $12 per M feet in other localities. The timber property under mortgage is appraised conservatively at $2.50 per M as against $3 to $6 valuation of similarly well located timber in other localities. The mortgage rate is less than $1 per M feet, or less than 36 per cent of the appraised value of the total security. The sinking fund is twice the mortgage rate. The property is practically immune from fire, the managers are successful men of long experience in the business, and their record in connection with a previous loan on another property has been exceedingly

* In this straight timber bonds differ from bonds of pulp and paper companies, in which a large part of the equity lies in the very expensive manufacturing plants and developed water powers. Pulp and paper mills are of a much more permanent nature than sawmills, which are at best but a transitory property.

good. It would be difficult to find an issue of industrial bonds affording greater security combined with so high a yield than such an issue of timber bonds. Such bonds may be bought for 99 to 99½ and interest.

III

Sinking Fund—Additional Equities—Guarantee—Bonus

Sinking Fund

As timber bonds are based upon standing timber, and as this timber is cut and the security thereby reduced, it is necessary to reduce the indebtedness in the same proportion. This is accomplished by means of the sinking fund, which is a stated amount of money the lumber company pays to the trustee for bond interest and the reduction of the indebtedness. For every thousand feet of timber which it cuts the lumber company must pay to the trustee a specified sum of money. The best issues provide that this sinking fund must be paid before any timber on each 40-acre unit has been cut, and that the payment must be based on the estimated stand of that 40, as determined by the cruisers' report. In other issues, particularly those of Eastern concerns, sinking fund payments are made at stated intervals of one to six months after cutting; in north woods operations payments are generally not required until the end of the previous winter's logging operations. It should be noticed what terms are used to describe the methods of paying this sinking fund. Some of the older bond issues state that the sinking fund is to be paid for timber that has been "cut and sold"; in other words, the sinking fund must wait until the logs have been manufactured into lumber and the product disposed of before it is reimbursed. This, of course, is improper. Generally speaking, however, abundant safeguards are thrown about the sinking fund, and in the best issues the conditions required for its payment are very rigid. There is one notable defect, however, in some issues, and the investor should guard against it. The sinking fund sometimes covers only timber removed in logging. Yet fires, windstorms, or an attack of insects may destroy large quantities of the timber, and thus reduce the security without compensation to the bondholders.

In the more recent issues by the best houses it is provided that in case timber is destroyed by any cause, the sinking fund shall be reimbursed the same as if the timber had been cut. This point should be insisted upon by the investor in any timber bond, as it is a protection he is entitled to.

It is most interesting to note in the various issues the rate at which the mortgage has been placed and the sinking fund established, in proportion to the appraised value of the timber. Let us first take some of the Southern pine issues.

The issue of an Arkansas concern is based mainly on shortleaf pine, which the appraiser values at $4 per thousand feet. The bond issue is made on the basis of only $1.81, and the company agrees to pay into the sinking fund for all timber it cuts the full appraised value of that timber, namely, $4 per M. Furthermore, the sinking fund is to be reimbursed before each 40-acre unit is cut. This arrangement will result in the redemption of all the bonds before one-half the timber is cut.

A Texas longleaf pine concern values its stumpage at $4.50, and has bonded it at the rate of $1.81. The sinking fund rate is $3.50.

Another Texas concern, with pine and oak, has mortgaged its pine at $1.70, although valuing it at $4, and its oak is mortgaged at $1.36. The sinking fund for both is $2.50.

One of the largest of all timber issues, amounting to $9,000,000, is at the rate of only $2 (which indebtedness has since been reduced to $1.76 through the sinking fund), although its timber is conservatively valued at $5. The sinking fund on this issue is $3.50.

A concern owning a large body of shortleaf pine in Arkansas values its stumpage at $4.50. The bond issue is at the rate of $1.96 and the sinking fund is $3.

Taking the above examples and a number of other issues which the writer has examined, we find that in Southern pine the average valuation placed by experts on longleaf is $4.42 and on shortleaf $4.12. The rate at which the mortgage has been placed, considering stumpage alone and disregarding other valuable equities, is $1.60, or only 37 per cent of the total appraised stumpage value. The sinking fund on the above issues is at the average rate of $3.46 per M feet, or more than twice the bonded rate, and 80 per cent of the appraised value.

A Chicago house which has placed a great volume of timber bonds shows that the indebtedness on a number of its issues has been reduced through the operation of the sinking fund as follows:

From	$2.00	to	$1.76	From	$1.27	to	$1.22
"	1.79	"	1.44	"	1.36	"	1.10
"	1.98	"	1.96	"	1.19	"	1.08
"	1.73	"	1.65	"	2.08	"	1.02
"	1.68	"	1.48	"	1.46	"	1.25
"	1.56	"	1 51	"	1.38	"	1.24
"	1.57	"	1.25	"	.81	"	.66
"	1.47	"	1.43	"	.49	"	.41
"	1.16	"	1.05	"	.38	"	.33

It is well to take note here of the peculiar operation of the sinking fund as it is applied to timber bonds. With the mortgage rate at 40 per cent to 50 per cent of the appraised value, and the sinking fund at 80 per cent of the appraised value, and with the estimated stand of timber from 20 per cent to 30 per cent below the actual amount, the result is that the entire bond issue will be retired usually before one-half the timber is cut. Also, as the indebtedness is reduced the value of the security remaining increases very considerably in spite of the removal of timber, so that in the later maturities the indebtedness of the property is only nominal. Take, for example, a California tract of redwood. The timber was appraised at $2.50 when the bond issue was made, but is now worth $3 to $3.50. The mortgage rate was only $1, and the sinking fund is $2. This sinking fund will pay off the indebtedness before one-half the timber is cut. It may be expected that before this issue is retired the security will have advanced close to $5 and the indebtedness reduced to 10¢ per M feet. Unfortunately none of the bondholders knows whether he will continue to hold his bond in this very desirable property, since all the bonds are optional.

Additional Equities

It has been stated in connection with the above that there are in most cases large equities beside stumpage on which bond issues rest. Particularly in the case of the well-developed properties of going concerns there are often one or more million dollars of investments in mill plants, machine and railroad shops, power plants, trolleys, logging railroad and equipment. These improvements, it should be noted, are vital to the earning capacity of the concern, and, with proper allowance for depreciation, constitute a valuable asset. The investor should not, however, give too great weight to the amount of investment in such improvements, but should consider as of first and foremost importance the amount and character of the stumpage, and next the character of the men behind the bond issue and their experience and record as timbermen. While mill plants and logging railroads are just as vital to the successful operation of a lumbering enterprise as rolling stock is to a railroad, yet their value exists only so long as the timber supply holds out. When the timber has been exhausted the improvements are worth only a fraction of what they originally cost. Besides, mill plants are extremely bad fire risks, as is indicated by insurance rates, which are frequently from 5 to 10 per cent. The investor should, therefore, determine whether the trustee is responsible for the maintenance of insurance on the mill properties. Conservative lumber companies make regular annual charges for

the depreciation of their plants. This is based upon the estimated life of the concern as determined by dividing its total stand of timber by its average annual cut (in addition, of course, it must charge for maintenance). It may safely be assumed that the value of the mill plant at the completion of operations, when all the timber is cut, will hardly be more than 25 per cent of its original cost, and this should be the maximum valuation upon which the bond issue should rest. In the case of the logging railroad and equipment, it should be noted that such railroads are necessarily temporary in character and of no value when the timber has been removed, except for what the rails and rolling stock will bring at a sale. Therefore the bond issue should not rest upon the face value of the logging railroad, but it should be assumed that such railroad, like the mill plant, will have become worth only a fraction of its original cost when the timber has been exhausted. The only exception that could be made to this rule is in the case of a number of logging or tram roads in the South which have become valuable as feeders to trunk lines and have been acquired by the latter.

The Guarantee

As additional security many timber issues, especially the later ones, are guaranteed by wealthy and responsible lumbermen. This guarantee is made generally in the case of timber properties in a more or less undeveloped state that have been acquired for future operations. Many of them are not so situated as to make them immediately accessible to present logging operations, and the bond interest must be met by funds derived from other sources. In such cases the investor should carefully ascertain the responsibility of the guarantees and their net worth. It should be added, however, that these guaranteed bonds are usually based on properties that will certainly be logged very shortly. The state of the lumber market when these bonds were issued may not have been favorable for developing the property, and the men who issued the bonds preferred to pay the interest charges out of other funds and wait until times were more propitious. Broadly speaking, however, every timber bond should be judged strictly on its own merits, irrespective of the guarantee. If the bond is a good bond it needs no guarantee to make it salable.

The Bonus

The advantages of legitimate timber bonds have become so well understood in the West and South as to make them readily salable, so that an issue floated by any one of the several conservative bond houses who

specialize in these securities soon finds its market. There are, however, a few issues which as a special inducement offer a considerable bonus in the form of a certain per cent of the common stock—usually 50 per cent. The offer of a bonus is usually an indication of watered stock. A timber bond, if it is a good bond, should sell on its own merits as a bond, without a bonus. Adding a bonus is like putting a prize in the breakfast food—the quality of the breakfast food may be regarded with suspicion. In nearly all cases the bonus is offered on issues of uncompleted properties where funds are needed to put in the mill plant and logging railroad. In several instances corporations with large timber concessions in Mexico and Central America offer large stock bonuses. Their securities will be let alone by the conservative investor.

IV

The Redemption Feature

Practically all timber bonds of merit include the optional or redemption feature—that is, they may be called and paid off by the concern issuing them on any interest date after due notice. Some bonds are callable by lot; others in regular order according to number; others in reverse of their numerical order—that is, the largest numbers are redeemed first. But since these largest numbers are the oldest maturing bonds, an investor buying a bond due in 20 years may have his bond paid off in six months! It is true that in some issues an attempt has been made to fix an interval during which no bonds will be redeemed, but this is always in the case of undeveloped properties where time is desired for construction.

The reasons why all timber bonds are short-term bonds of uncertain maturity are most interesting. "The feature of short maturities," writes a prominent timber bond house, "seems to be unavoidable in connection with loans to the large timber interests. From the fact that they are cutting timber on land covered by mortgages it is necessary to require a sinking fund deposit, and the serial form of bond is most desirable, as it does away with tying up funds in the hands of the trustee."

The above argument is sound, so far as it goes. Let us, however, analyze the matter a little further. The timber companies who have mortgaged their properties during the past 10 years realize the inevitable advance of stumpage prices and the enormous future value of large, well-located timber tracts. These men know that before the maturity of their oldest bonds the security will have grown to many times the mort-

gage amount, and that the investing public will realize better than now the attractiveness of timber bonds. Timbermen, therefore, prefer to pay a premium for the privilege of calling and redeeming their present bonds rather than burden their operations with a high rate of interest extending over a long time. This is why the sinking fund is so high. Consider the Southern pine concern above referred to, which has mortgaged its properties for $1.80 per M feet, the timber being actually worth and salable at $5 per M feet, with an absolute certainty of appreciation in the next few years. By paying back to the sinking fund $4 for what it cuts, this concern is in a position to retire its bond issue very rapidly, should that be desirable for its own interests. In hard times, when money rates are low and profits small, the company will greatly reduce its cut and pay no more into the sinking fund than necessary to redeem the bonds that are about to mature; but when times are good, demand is booming, profits very great and everybody making money, the company will greatly increase its cut, putting in more logging camps, running the mill double shift, and thus acquire a sinking fund which will enable it to retire a great part of its bonds. This puts it in a position when the reaction sets in and times again grow hard to float another bond issue, if deemed expedient, on much more favorable terms than the first.

The feature of short and uncertain maturities, so desirable to one class of investors, is wholly undesirable to another. It would, for instance, be injudicious for the head of a family desiring an investment, the yield of which would support his widow or children after his own death, to place his money in timber bonds. Such bonds would likely be paid off before maturity. In any event, the inexperienced holders would sooner or later be compelled to take the perilous step of reinvesting their funds. Short-term bonds do not meet the needs of the great class of conservative investors, but only the special needs of banks, of business men and others who are capable of exercising discretion in their choice of a security. In times of business depression, when bonds of all classes are cheapest, it is considered to be the part of financial wisdom to buy long-term bonds, just as it is judicious in times of great prosperity to put surplus funds into short-term notes or in paper maturing at an early date. Timber bonds have many strong points to recommend them, but it is well that their limitations should also be thoroughly understood.

Reference was made above to the high sinking fund rate and the opportunity afforded lumber companies to retire their indebtedness by increasing their cut. The caution which must be exercised in that plan is that the sinking fund be not too high, for the concern which agrees to pay to the trustee for the redemption of its bonds a certain specified sum per M

feet of timber cut is virtually agreeing to charge its operations with that price on its stumpage, and the price may be too high to admit of any profit in periods of business depression. The investor should not be misled by the rate per M feet of the sinking fund into believing that the higher the rate the greater the security; in some cases the contrary may be true. A high sinking fund allows the company to retire its bonds quickly, but may be so high as to embarrass the concern when lumber prices are low. Before fixing the amount of its sinking fund the company should carefully consider what is the highest price it can possibly afford to pay for stumpage during a period of dull times, when demand is very sluggish and prices are as low as they can reasonably be expected to reach.

This factor changes widely with the section of country in which operations are being conducted and with the kind of timber cut. In the case of cypress, yellow poplar, spruce, white pine and other woods whose amount is limited and ownership of which is in strong hands, prices are well maintained at all times, and the sinking fund may be fixed at a fairly high rate. But in the case of Douglas fir, Washington red cedar, Southern pine, hemlock, etc., where there is usually overproduction and violent price fluctuations, and where profits may be entirely wiped out during dull times, the fixing of the sinking fund should be done with caution. Personally, the writer would not favor a sinking fund on Douglas fir at present in excess of $1.75 for the very best timber. For ordinary timber $1 is quite high enough. The sinking fund for longleaf pine should rarely exceed $3.50. In the case of Northern white pine or the Idaho white pine, a sinking fund of $5 to $7.50 for the former and $4 to $5 for the latter would be conservative under ordinary circumstances.

The ideal function of the sinking fund is to reduce the indebtedness at the same rate at which the security is reduced, but in practice this sinking fund is so large in proportion to the mortgage as to retire the bonds long before all the timber is cut.

The next important step in the process of improving timber bonds will likely be taken in the direction of lengthening the maturities. Whenever conditions have become right for private owners of timber to conserve their holdings, the character of timber bonds will reflect the change in a reduced sinking fund rate, a different application of that sinking fund and the gradual elimination of the optional feature. In the meantime it is not improbable that various substitutes will be found for the present arbitrary method of redemption. It may, for example, be found feasible to issue timber bonds convertible when called into cumulative

preferred stock of the company at the option of the holder; or the sinking fund may be invested in additional timber under the supervision of the trustee at a fixed rate, the lumber company paying the additional amount required.

V

The Expert Examination

The backbone of a timber bond issue is the timber on which the mortgage rests. No bond house, bank, or other conservative investor would think of investing in the securities of an electric light and power concern, for example, or a gas or traction company, without having previously read and digested the report of the expert engineer who examined the property. It is equally important that the report of the timber appraiser should be read and digested, and that due weight be given to the reputation of the examiner for his expertness in such matters and for his integrity.

In the past too many bond issues have been made upon an insufficient examination and report. This was mainly because the bond houses selling the securities were not timbermen and lacked adequate knowledge of the factors which go to make timber valuable. It is not altogether a question of how much timber there is on the tract. The problem of its character and quality is equally important. Its location with reference to logging, to the cost of putting in an adequate transportation system, the cost of getting logs to the mill, the problem of storage, the cost of milling, location of the plant with reference to markets, character of the management, etc.—all these factors, or any one of them, may be vital. Such matters must be studied thoroughly and passed on by the expert who looks over the property. It is self-evident that this is no task for the mere land-looker and timber cruiser. Yet in the past a considerable volume of timber bonds were actually sold on no more thorough examination of the bonds than that which an ordinary timber cruiser was capable of giving it. Issues of most Eastern concerns are deficient in this respect. Thus we find that one of the largest Eastern bond issues, that of a New England concern, is based upon the cruise of a land-looker employed by the lumber company. No logging and milling costs whatever are given, no detailed description of how the timber is handled—nothing even approximating the definiteness and precision of an engineer's report. In other issues the investor is asked to content himself with the mere statement that the timber "has been examined by competent cruisers."

Western bond houses which specialize in these securities have performed a notable service to their business by raising the character of the examination which is now given to properties whose bonds they undertake to sell. The best houses employ experts who carefully examine the timber or supervise the examination of it, investigate the whole property, and report fully on its more important aspects. It is comparatively simple to find men capable of making rough estimates of the amount of timber on a given tract, but quite a different thing to secure men able to size up a large lumbering proposition and determine with good judgment what are its favorable and unfavorable points.

The average investor in timber bonds will not care to examine into the technical features of a timber cruiser's work. He will be mainly concerned in knowing that the cruise was thorough. Any Western bond house will gladly furnish the full reports of its cruisers on any of its timber bond issues. In many cases the experts employed by these houses do not actually cruise all of the timber, but merely check occasional forties cruised by the lumber companies. Inasmuch as the expense of cruising and appraising the property falls entirely on the company seeking the loan, there is no incentive for the bond house to slight this part of the work, and as a rule it is very thoroughly done.

The appraiser is expected to examine carefully into the efficiency of the mill plant, the logging plant and equipment, and the management as a whole. He goes over the mill plant and inspects its location with reference to convenience and economy, the character of construction, kind of machinery used, etc. He should also inspect the lumber to learn whether it is properly manufactured and piled. The location, character, and capacity of the dry kilns, planing mill, etc., are also considered.

An inspection is also made of the logging department. This includes methods of handling logs, transportation system, and costs. The inspection should determine whether the cutting is efficiently and not wastefully done; whether everything merchantable is got out of the woods, all logs picked up, the skidding and loading and the transportation economically conducted.

In the best organized concerns there are always a few weak points. One of the most important features to examine is the selling end of the organization. The best bond houses insist on a careful audit of the books of a lumber concern seeking a loan. The auditor's report should show comparative costs, gross profits, expenses, net profits, etc., covering several years.

For the conscientiousness with which all such work is done the investor must depend absolutely on the bond house.

VI

Hazards from Fire, Windstorm, and Insects

The principal risk which a purchaser of timber assumes is from destruction or damage to his property by fire, insect pests, or windstorm. These hazards vary in different parts of the country and with different species.

The most conspicuous, though not in all cases the gravest danger, is that of forest fires. Every summer and fall the newspapers contain many dispatches concerning the destruction of timber by fire, and estimates are often attempted at the time as to the value of such timber destroyed. Such estimates are almost always the wildest kind of guesswork, and no credence whatever is to be placed in them. The amount of timber destroyed by a fire is impossible to ascertain in any definite manner until a considerable time after the fire has passed through the woods, and then only by the most careful inspection. Fires vary greatly in their intensity and species differ in their susceptibility to fire. A fire may pass through the woods, burning over only the grass and underbrush and killing a few small seedlings, leaving the mature timber unharmed. Such fires are habitual in the Southern pine forests, and every one takes them as a matter of course. The longleaf, loblolly, or shortleaf pine, are great fire resisters, and unless the tree has been tapped by the turpentine man no damage results. It is true that the young growth is killed or kept down, but such material does not figure in the valuations on which timber bonds rest.

In the Lake States and in the Rocky Mountain country, and the east slopes of the Cascade Mountains, forest fires are apt to be especially severe. White pine and hardwoods are species particularly susceptible to fires, and in regions where such timber grows the fires are apt to be most frequent and difficult to contend with. For example, the year 1910 was an especially bad year in Idaho and Montana, and great losses were sustained by timber-land owners and by the Government. The latter lost several billions of feet of fine timber on its National Forests in these two States.

On the Pacific coast much timber is lost every year by forest fires. It is interesting to note the references in the bond circulars concerning Douglas fir properties, that because such timber is "in the fog belt" it is not in danger from forest fires. It is true that the fire season on the coast is comparatively short, lasting, as a rule, from early in July until

late in October; but in these three months, in an especially dry year, great destruction may occur.

There are no reliable figures on the damage sustained by forest fires. Each year the Government reports the total number of fires on its National Forest, and endeavors to give the acreage burned over and the amount of timber destroyed, but such figures are not convincing, inasmuch as they can give no reliable estimates of damage done. Besides, the Government owns but a small percentage of the standing timber of the country, and on the whole takes much better care of it than does the private owner. The following figures show the amount of land burned over for each 1,000 acres under administration of the Forest Service in recent years:

1905	2.86 acres.
1906	1.26 "
1907	1.40 "
1908	2.46 "
1909	1.86 "
1910	25.87 "

It will be seen that in spite of the decided improvement made in fire protection service in recent years, a bad year may result in fires many times more extensive than in average years.

It is not possible to insure standing timber against fire in this country.* The bondholder, therefore, must assume this risk, it being stipulated in the best bond issues that for timber destroyed by fire the sinking fund must be reimbursed the same as if such timber had been cut and manufactured. A difficulty here is that a great deal of timber may be fire-killed without the trustee knowing anything about it. Fires do not ordinarily strip a large tract of its entire stand or any considerable part of it. A forest fire usually burns in spots, burning over a section here, a forty there, killing much timber in some places and very little in others. It may be a year or two after the fire before the exact amount of damage done may be ascertained. The fire may occur in places where it is feasible to cut the burned area before the worms get in and the trees deterio-

*The only instance the writer knows of in which a lumber company on this continent has insured standing timber is that of Price Bros. & Co., Ltd , Quebec. This concern is over 100 years old, and more than one-half of its $5,000,000 stock is in the hands of the Price family. It has bonded its properties in the sum of $6,000,000. The timber limits have been divided into fifteen groups and fifteen policies have been taken out in Lloyd's against forest fires. The company also maintains a fire patrol system and is practicing a system of conservation of its timber holdings in the Province of Quebec.

rate; or it may be in places where logging the tract would be attended by such expense that the whole proposition had better be abandoned and the owners pocket their present loss.

Within the past few years a great deal has been done by timber-land owners, both individually and by means of organizations, to limit forest fire losses. Big timber companies, especially in the West, almost invariably maintain fire patrols in the dangerous months. Such concerns have also united and formed associations with organized crews of patrolmen and fire fighters, dividing the expense of the work pro rata according to acreage. The central organization of these various State organizations is the Western Forestry and Conservation Association, whose purpose is to "afford central facilities for all associations devoting organized effort to conservation of forest resources, reforestation, or protection of forests from fire in Montana, Idaho, Washington, Oregon, and California."

To summarize: It is impossible to state in any definite way the amount of fire hazard assumed in the ownership of standing timber, but there are very few instances of total destruction of timber over a large area, and the danger is greatly decreased by proper patrol. In the Southern pine regions the danger from fires, as far as merchantable timber is concerned, is practically negligible. On the Pacific coast, in Douglas fir forests, and in the redwood forests of California, the danger is slight, and is greatly reduced by membership in one of the associations organized for fire protection. In the Lake States, in Idaho, Montana, and eastern Washington and Oregon, the danger is much greater. Therefore the investor, before purchasing timber lands based on such properties, should assure himself that:

1. The company maintains an adequate fire patrol system of its own or belongs to one of the associations organized for fire protection.

2. The company has stipulated in its mortgage to reimburse the sinking fund for timber destroyed by fire at the same rate as if the timber had been cut and manufactured.

3. The whole property is so accessible that in the event of a serious fire it would be feasible to put in logging camps and get the timber out before serious deterioration occurred. This point should invariably be covered in the expert examination of the property.

The amount of damage done to forests by windstorms or by storms, followed by insect attacks, is also considerable, and constitutes in some regions more of a hazard than fire. The writer has in mind a particular instance. On the Menominee Indian Reservation, Wisconsin, a great windstorm in July, 1905, uprooted and otherwise destroyed about

60,000,000 feet of hardwoods, hemlock, and white pine. Before this timber could be logged and manufactured a large part of it had become completely worthless.

In September, 1906, a vast amount of pine, probably about 3,000,000,000 feet, was blown down in Mississippi, and much of this timber was a total loss.*

In May, 1907, near Tuscaloosa, Ala., a storm blew down about 800,000 feet of pine.

On April 24, 1908, a great cyclone passed through Mississippi and Alabama, blowing down a strip of timber from one to two miles wide in one of the finest timbered regions in these States. Many millions of feet of timber were destroyed. About the same time two storms occurred in Arkansas, both of which were very destructive to the pine timber.

In the Southern pine woods timber blown down in the summer is at once attacked by insects, which quickly cause great deterioration; so that, considering the increased cost of logging caused by the splintered wreckage scattered about in the woods, the loss is often a total one. In most cases, indeed, lumbermen will decide against handling timber that has been for a few months lying on the ground as a result of a storm.

While forest fire hazard is so conspicuous in some sections of the country that the mortgage usually protects the timber bondholder against such a contingency, yet insect damage is too often disregarded as being too remote to be considered. Yet, in the light of past experience, it would seem to be wise to embody a provision in the mortgage protecting the bondholders from all damage to timber by natural causes, such as fires, storms, insect attacks, etc. In carefully drawn mortgages this is now done. And yet this danger still presents itself, namely, destruction of timber by attacks of insects is generally so inconspicuous a happening that it may go on for years and cause a great deal of damage without special attention being called to it. It is, therefore, highly desirable that the trustee for a bond issue should maintain a systematic inspection of timbered areas subject to its bond issues, and that its inspectors should make periodic inspections not only of the cut-over areas, but over the entire forest as well.

VII

Conclusions

There are fashions in securities, as in other merchandise. At present timber bonds are highly regarded, and quantities of them are being sold.

* See Bulletin 58, Part IV, Bureau of Entomology.

The private investor who does not care to place his money these bad times in a business venture, and who is not satisfied with the low interest rates which banks are now paying, is attracted by these features of timber bonds, namely:

1. The security, which is usually ample.
2. The interest, which is 6 per cent.
3. The probability of having his bond called before maturity at a premium.
4. The fact that bonds may be purchased maturing at a time when the investor anticipates using his funds for some other purpose.

Timber bonds as a commodity afford unusual opportunities for profit. The bond market has been good, and coupled with this is the fact that for a long time the lumber business has been in a state of depression and the weaker concerns are badly in need of funds. These conditions have resulted in a large increase in the number of concerns dealing in timber securities. Bond houses and private banking firms are the legitimate sources of relief for timber-holding concerns who desire raising money on their properties for legitimate purposes. As a matter of fact, the dull times have driven a number of lumber companies, including even wholesale concerns, into the timber bond business. Some of the issues offered for sale by such concerns are utterly unsafe and the bonds will likely default. As an example of the character of offerings of such concerns the following will serve:

A Western concern is now offering bonds on Pacific coast timber lands which are not being operated. The company buys a timber tract, cruises it, and issues bonds on it, after having conveyed the property by trust deed to a local trust company. The company agrees to pay a low rate of interest on the bonds, and, in addition, to turn over to the bondholders two-thirds of any profits arising out of the sale of the property, retaining one-third of such profits for its own services. In brief, the company hopes to attract investors by the opportunity of sharing in the rise of Pacific coast stumpage values. The above proposals do not come within the narrow restrictions of the investment principle. They are, on the contrary, speculation of a particularly dangerous sort. Of course, no one with any knowledge of Pacific coast stumpage would be apt to risk his money in any such ventures, particularly after analyzing the loose terms with which the proposals are put forth. Such literature is designed to catch the unwary and uninformed.

The following rules for the guidance of investors in timber bonds are simple and fundamental:

1. Buy no timber bonds except such as are offered by the established bond houses and banking firms that have dealt in such securities for at least three or four years, understand the business, and recommend their issues.

2. Buy no timber bonds that are not regarded by your bank as safe purchases. Consult your bank in every case.

3. Buy no timber bonds, as a rule, carrying with them a bonus of stock. Such bonds may be, and often are, safe purchases, and the stock may ultimately become valuable. But they are not the most conservative issues and come within the speculative class.

4. Under no circumstances buy timber bonds which embody the opportunity, real or supposed, of participating in speculative profits from the sale of the bonded properties.

5. Preference should be given to bonds secured by properties of operating lumber concerns, especially those that have shown for a long period substantial profits in bad as well as in good times. It is an especially strong point in a bond issue where it can be shown that the mill has, in periods of depression, when the market was unprofitable, curtailed its output greatly. Such a policy ordinarily shows that the concern is in an independent position.

6. Other things being equal, it is better to purchase bonds forming part of a large issue than of a small one, for the reason that the former are more readily marketable and more apt to command a premium.

7. Bonds on properties least subject to fire, windstorm, and insect attacks are preferable. In every case, however, such hazards should be assumed by the company issuing the bonds.

THE CATALPA SEPTUM

A Factor in Distinguishing Hardy Catalpa

BY WILLIAM H. LAMB

(Contributed)

The purpose of this discussion is to select a single character, by means of which those who are unfamiliar with the technique of botany may be able to distinguish hardy catalpa (Catalpa speciosa) from the common catalpa (Catalpa catalpa).

Many plant species are not distinguished by one character alone, but by the combination of numerous small but constant differences. Unfortunately this is true of our two species of catalpa. Very unlike in silvical qualities, these two forms are extremely similar in botanical characteristics. In fact, the leaves, flowers, seeds, and even the pods, are so nearly alike that the identity of a specimen may often prove puzzling, even to one who has an excellent knowledge of our forest trees.

It is practically impossible to distinguish between the two species of catalpa from the leaves alone. It is true that the leaves of common catalpa are stronger scented and not quite so long pointed as those of hardy catalpa, but these distinctions are very slight, and, being entirely relative, are practically of no value.

The flowers furnish a better means of identification. Those of common catalpa are thickly spotted on their inner surface, and the lower lobe of the corolla (the white part of the flower) is not notched, while those of hardy catalpa are not so thickly spotted and the lobe of the corolla is slightly notched. But catalpa flowers are fragile and only available for a short time in the spring, and even then such distinctions are of little value except as a means of comparison.

Identification from the seeds alone is most difficult. These two species have seeds so very much alike that although the two forms may often be separated when placed side by side, yet with a single specimen at hand specific identification is most precarious.

The pods are essential for positive identification; but even with these it is difficult to distinguish the species because of their extreme variability in size. In general the pods of hardy catalpa are larger than those of common catalpa. However, pods of common catalpa are found prac-

tically as large as the largest of the hardy catalpa. According to Dr. Sargent,* the pods of hardy catalpa are 8 to 20 inches long and those of common catalpa 6 to 20 inches in length. So the size of the pod is absolutely of no value as a distinguishing feature.

There is, however, one character which seems to be entirely dependable—the septum.

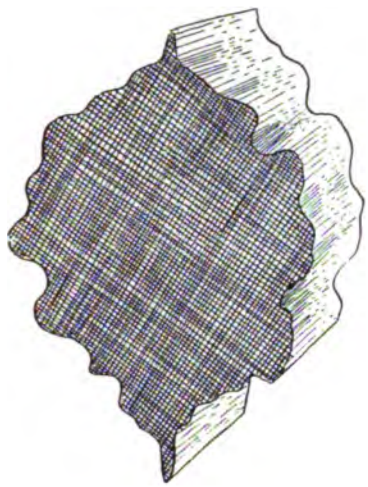

FIG. 1.

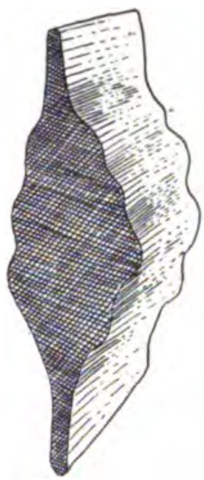

FIG. 2.

The septum is the long, wrinkled partition in the pod, along which the seeds are arranged. This septum, or pod-partition, may be flat or rounded in general outline, and this variation in shape furnishes a valuable means of distinguishing hardy catalpa.

The septum of hardy catalpa, an enlarged section of which is shown diagrammatically by figure 1, is rounded in general outline. The septum of common catalpa (figure 2) is only thickened along the middle. On account of the fact that the septum is very irregular and not of uniform thickness throughout, places may be found in the septum of hardy catalpa that are considerably flattened, approaching the shape shown by figure 2, but no pod of common catalpa has ever been observed by the writer with a septum as thick in any place as shown by figure 1.

This important distinction has never been sufficiently emphasized, and will, it is believed, prove to be the most dependable single factor in the identification of hardy catalpa.

* Sargent's Silva VI, 87, 90.

CHAPARRAL AREAS ON THE SISKIYOU NATIONAL FOREST

BY H. E. HAEFNER

(Contributed)

The question of the management of the large chaparral areas on the National Forests is one of much interest to many people, and it is one that has been discussed by all classes of people that are at all interested in any way with National Forests, either as miners, stockmen, ranchers, lumbermen, or hunters, or as rather disinterested persons one thousand miles away from the nearest National Forest. The last fire season was one of the severest in many years, causing the loss of much life and property and bringing forth much criticism against the management of the National Forests by the Forest Service. The old story of burning over these brush areas yearly, so that a large fire could not occur because of the lack of available material sufficient for a large fire has been told again and again. Were these slopes not suited for the production of any other class of material than chaparral, and were the extent of the damages done to the soil by fire, in the way of destroying humus, transforming plant food to a form unavailable for the growing plant and seriously injuring the physical condition of the soil, so that conditions for growth are less favorable, not known, this method of handling the situation might have some commendable features. Fire, however, means destruction, and that which is destroyed often can only be regained with difficulty. The accumulation of humus beneath a heavy stand of timber can, perhaps, not be replaced in less than one hundred years and longer, and the nitrogen that escaped as a vapor can only be replaced after the reëstablishment of favorable forest conditions. The loss not only includes the loss of the present forest cover, but includes the more important and greater loss of accumulated fertility of the soil and a certain loss of the soil's susceptibility for favorable plant growth.

The purpose of this report is to try to show that these chaparral areas have other possibilities, and to suggest methods of handling them.

Chaparral Situation

The reforestation of the chaparral areas is one of the big problems in Forest management today, and will continue so for many years in the

future. On the Siskiyou National Forest there are approximately 327,000 acres, exclusive of the Smith River watershed, out of 1,302,393 acres that are covered with chaparral of many species, and on other Forests the percentage of the chaparral areas is undoubtedly as large and covers as wide a range of conditions.

The Siskiyou National Forest occupies a region where conditions are favorable to tree growth. The annual precipitation, although not well distributed during the growing season, is sufficient; the climate is mild, with a comparatively narrow range between maximum and minimum temperatures; exposure, generally speaking, is not severe, and soil conditions, while not the best throughout, are generally favorable to tree growth. In observing the undergrowth under stands of timber and the chaparral species on a near-by brushy slope, many are found to be the same, and hence, with the evident favorable conditions present, the chaparral areas should not form the large acreage that they now do. The cause of their existence, however, is not difficult to ascertain, and is seen on every hand. The charred stump, tree trunk, and fallen log tell plainly that fire was the cause, and has done its work.

Could a man have seen this Southern Oregon country before the original fires along the coast occurred, he would have seen a Forest practically continuous and not broken by the brush areas. At that time the area now included within the boundaries of this Forest probably carried more than again as much timber than what it now carries (roughly estimated at 12,000,000,000 ft. B. M.), and the stand probably approached more nearly a normal stand than anything that we can see today. When these original fires occurred is not known, but they probably did not occur until after the white man reached the coast, and a part of the responsibility for their occurrence might be laid upon the early Hudson Bay trapper. Since then there has been much burning by Indians, miners, hunters, and stockmen, so that little trace is left of the virgin stands that once covered these areas. With each fire much humus was destroyed and the soil sapped of its fertility, so that each succeeding forest cover that established itself after a fire was either composed of more inferior species than that which composed the preceding forest cover, or else they made a less vigorous growth. Such, however, was not the case on all areas. On occasional sites, the burning was followed by a heavy seed crop and periods of strong winds, so that seed was distributed over considerable areas and a dense stand of reproduction has sprung up which now forms a stand of timber of small commercial size that appears to be approximately 100 years old. Stands of this nature cover relatively small areas.

To bring this Forest to its highest state of development and productiveness will require that these chaparral areas be restocked with a stand of commercial timber, and that the now large area, approximately 300,000 acres, that is classed as woodland, be more fully stocked so as to enter the class of commercial timber. On all the areas of these two classes of forest cover there are, of course, areas that it may not be possible to restock with a stand of timber having commercial value, but such areas should be reduced so as to include only those sites unfavorable for tree growth from practically all standpoints. This is a possible achievement, and one that should be kept in mind, and when such a time in our forest management is reached this forest will have from 1,000,000 to 1,100,000 acres of commercial timber out of the present area of 1,302,393 acres, and the estimate of merchantable material will at least be double to what it now is.

The most common of the chaparral species are given in the following list, in which they are arranged according to their demands for soil quality, and in which the ones that head the list compare favorably with some of the most valuable commercial species of trees in this respect:

Prunis emarginata (Douglas) Walpers, Bitter Cherry (3).
Ribes sanguineum, Pursh, Currant (6).
Corylus californica (A. D. C.), Ross, Hazel (8).
Kunzia tridentata, Spring, Buckbrush (21).
*Quercus californica (Tarr), Cooper, California Black Oak (16).
*Rhamnus purshiana, De Candolle, Cascara, Shittim Wood (7).
*Quercus garryana, Hooker, Oregon Oak (15).
*Umbellularia californica (Hook & Arnt), Nuttall, Oregon Myrtle (5).
Ceanothus sanguineus, Pursh, Buckthorn (27).
Gaultheria shallon, Pursh, Salal (13).
Rubus parviflorus, Nutt, Thimbleberry (2).
Rubus spectabilis, Pursh, Salmonberry (1).
*Cornus nuttallii, Audubon, Western Dogwood (18).
*Sambucus glauca, Nuttall, Blue Elderberry (11).
Viburnum ellipticum, Hook, Arrowwood (28).
Salix nuttallii, Sargent, Nuttall Willow (9).
Salix amygdaloides, Anderson, Almond Willow (4).
Quercus sadleriana, R. Brown Campst., Sadler Oak (20).
Berberis aquifolium, Pursh, Oregon Grape (12).
*Cercocarpus parvifolius, Nuttall, Mountain Mahogany (26).
Myrica californica, Chamisso, California Myrtle (29).
Vaccinium ovalifolium, Smith, Blue Huckleberry (30).
Vaccinium parvifolium, Smith, Red Huckleberry (22).
*Castanopsis chrysophylla (Hook), A. De Candolle, Western Chinquapin (33).
Rhus diversiloba, Farr & Greene, Poison Oak (17).

Amelanchier alnifolia, Nutt, Serviceberry (31).
Ribes watsonianum, Koehne, Gooseberry (10).
Ceanothus velutina, Douglas, Sticky Laurel (19).
Rhododendron californicum, Hook, Rose Bay, Rhododendron (14).
Philadelphus lewisii, Pursh, Syringa (32).
*Arbutus menziesii, Pursh, Madrona (23).
*Quercus chrysolepis, Liebmann, Live Oak (25).
*Quercus densiflora, Hooker & Arnott, Tan Oak (24).
Arctostaphylos tomentosa, Douglas, Manzanita (34).
Arctostaphylos uva-ursa, Spring, Kinnikinic Manzanita (37).
Chemaphila umbellata, Nutt, Prince's Pine (35).
Acer glabrum, Torrey, Dwarf Maple (36).
Juniperus communis, Linnæus, Dwarf Juniper (38).

NOTE.—* designates species that reach tree size under more favorable conditions and at greater age.

Numbers indicate arrangement of species with regard to their demands for soil moisture.

The above list includes only those species which have been identified by the writer.

The chaparral species are also found as undergrowth beneath stands of timber, which goes to show that their demands for many of the requisites of tree growth are the same, or very similar, to those of the different subtypes of forest.

Geological Formation

The growth and the distribution of species is well known to be influenced by the character of the soil, which, if of a residual nature, is more or less dependent upon the underlying formation from which it originated and upon the accumulated amount of humus that it possesses for its fertility and its value and classification as a timber soil. The classification of the different soil types in the Forest is essential to the wise management of the chaparral areas and to discover the possibilities of the chaparral site and the nature and value of the forest crop that it may ultimately produce.

An endeavor has been made during the past season's field work to roughly divide the Forest up among the principal geological formations that underlie it, and to show their respective natural abilities to produce timber. The influence of site on tree growth is a disputed question, since the effect of other closely related factors, such as the accumulated organic matter in the soil, has not yet been accurately determined. However, it is apparent on this Forest that the best soils are on a formation that usually disintegrates and decomposes into a soil of much fertility. Our heaviest stands occur on a soil underlaid with a sandstone or lime-

stone formation. The Forest has roughly been divided into four main formations, which act more or less as criteria of what their respective sites can produce. These formations, necessarily, are broad terms, and cover several formations, perhaps, that are distinct from each other, but which belong to the same general class of rocks. For example, the term "granite" will include the different granites, basalts, and gabbros, and the "sand and limestones" will include all sandstones, limestones, and shales. The four formations are as follows: Sand and limestones, granite, porphyry, and serpentine, and are arranged according to their apparent ability to produce timber.

Sand and Limestone Formation:

Location: These formations are found on the northwestern part of the Forest throughout the south fork of the Coquille River, in Townships 30 and 31 S., R. 13 W., on the watershed of Sixes and Elk Rivers, Lobster Creek, and on Lower Rogue River; along the west side of the Forest on Hunters Creek, Pistol River, Lower Chetco River, and practically over the whole of the Winchuck watershed; and on the east side at the upper watersheds of Deer, Sucker, Williams, and Mungers Creeks, in Townships 38, 39, 40, and 41 S., R. 6 W., and parts of Townships 39 and 40 S., R. 5 W.

Soil: The soil of these formations is usually a deep black, clay loam, where it has not been subjected to a loss of its forest cover by fires. On the west side of the Forest it supports a heavy growth of vegetation in addition to a heavy stand of timber. On the east side this formation supports a heavy stand of timber, where fire has not done its work, but here, with a noticeable less amount of precipitation, the stand is not as heavy as on the west side of the Forest.

The effects of fire over this formation are very evident. In the timbered areas where few or no fires have occurred the humus content of the soil is high and the soil is of a loamy nature, as above noted, while on the slopes that have been subjected to fire the humus content of the soil has been lost and the soil is of a stiff, clayey nature.

The Forest: Throughout the sandstone and limestone formations the Douglas fir subtype is dominant. Along the streams on the western side of the Forest the Douglas fir forms a subtype with the Lawson cypress and occasionally with the true firs and hemlocks at some of the higher elevations. On the Winchuck, with the redwood, it forms a subtype over a part of the watershed, and eastward, against the Illinois River and around Bear Camp, in T. 34 S., R. 10 W., it forms a subtype with sugar pine. In the eastern part of the Forest the stand is principally

Douglas fir, with sugar pine and fir on the higher slopes. These subtypes, taken together, are secondary to the subtype of Douglas fir in importance.

In the region of the heavier rainfall, on the west side of the Forest, the timber grows large and is of good quality, and heavy stands of timber should be produced over large areas. Fir reaches 6 feet in diameter, and Lawson cypress, on the Coquille, as great a diameter, while on the Winchuck redwood reaches 10 and 12 feet in diameter, and Douglas fir in 25 years reaches a height of 87 to 100 feet and a diameter of 10 to 12 inches inside the bark at a stump height of 2 feet above the ground. Intermediate parts of this formation, on Pistol and Chetco Rivers, may not be as rich potential timber land, but should not prevent the classification of a part of this formation as timber land of the first class, and the remainder as timber land of the second class.

Chaparral Situation: Within the limits established for this formation many chaparral areas occur, the largest of which are found on the Winchuck watershed, on Pistol River and Hunters Creek, around Bear Camp (T. 34 S., R. 10 W.), and at the head of Deer and Mungers Creeks (T. 38 and 39 S., R. 6 W.). They also occur in greater or less size on many other parts of this formation. The chaparral, for the most part, includes those species that are more or less exacting in their soil and moisture requirements, and, therefore, include the species near the head of the list and those with the lower numbers. Exceptions to this may be found throughout T. 38, 39, and 40 S., R. 6 W., where the rainfall is much less than near the Coast, and here the species include many of those found on the poorer sites.

In the Coast region growth is very rapid, and these species soon cover the ground and form so dense a stand that it is often difficult to travel through them. Ceanothus especially reaches a large size, 2 to 3 inches in diameter and 10 to 12 feet in height, and other species of brush reach a size only slightly less than this. This kind of stand is slowly but surely building up the humus content of the soil and is preparing it for a future timber crop of much greater value. It, however, prevents the reproduction of valuable species by its occupation of the ground, except by a long process of natural forest extension, which will occur just as rapidly as more normal forest conditions are reëstablished and by a succession of these short-lived chaparral species which will finally give way to the encroachment of valuable forest species.

Management of the Chaparral Areas: In the management of the chaparral areas one of the principal and all-important considerations to keep in mind is that of fire. Each fire, as is known, robs the soil of

some of its fertility, destroys the accumulated humus on the surface of the ground and changes much of the available plant food to an unavailable form. Repeated fires will finally reduce the richest soil to one of practical sterility; not so, perhaps, by lack of the elements that are of most importance as plant food, but because of their occurring in chemical combinations that are unavailable for the use of the plant and because of the absence of the humic acids and micro-organisms that play so important a part in the preparation of plant food for the growing plant.

On the sandstone and limestone formations the Douglas fir is the dominant tree, and the reforestation of the chaparral area resolves itself into a question of securing reproduction of this species (and that of the redwood over a restricted area on the Winchuck watershed). It is now known that Douglas fir reproduces readily where its seed can come in contact with the mineral soil. This can be secured by broadcasting on a fresh burn or by a method of sowing that involves the partial preparation of the soil, such as seed spot or strip sowing. These latter methods are practical methods where the stand of brush is not too dense or too high, so that the cost of cutting out brush might not reach such a figure as might make them impracticable. In cases of this kind the area could be burned under careful supervision, which should be followed by broadcast sowing or the practice of planting nursery-grown trees, or transplants in clumps at regular intervals on prepared areas in the chaparral could be followed. Another method which might prove of interest is that of helping out the natural extension of the forest to these non-productive areas. This can be accomplished by partially preparing the ground close to seed trees or along the edge of the forest to such a distance as the seed will be disseminated by the wind and depend upon nature to do the sowing, or to burn a strip on the windward side of the edge of the forest, the width to be equal to the distance of seed disseminaion by the wind. This method should prove well suited to the smaller areas that are more or less surrounded by timber. It is, however, only applicable on heavy seed years and to only those species whose seed are widely disseminated by the wind, such as Douglas fir. The work of reforestation should be begun on the most favorable areas and proceed to the most difficult ones, and all advantage possible should be taken of nature's methods of carrying on this work.

Granite Formation:

Location: The formations of a granite nature occupy large areas near the central part of the forest, from east to west, at the head of the

Illinois River, and more or less non-continuous areas in the northwestern part of the Forest.

Soil: The soil is usually a clay to a loamy clay, and generally carries much broken rock throughout. It carries less organic matter, as a rule, than does the soil of the previously described formation, except on certain small areas in the western part of the Forest. The rock disintegrates very slowly and the mineral nature of the soil is apparent from this slow breaking up and resistance of these granite rocks.

This granite soil is capable of supporting fair stands of timber where a thorough disintegration of the rock materials has occurred and fire has not robbed the soil of its humus. Where rock exposure is common and much broken rock occurs, the stand of timber is usually of small diameter size, but of fair height, and appears to be slow growing, which on many sites seems conducive to the production of a good quality of material. Fire reduces these soils to soils strongly mineral, which are, in that condition, incapable of producing heavy timber. Granite soils should rank as second class in timber production.

The Forest: The granite soils generally support subtypes of Douglas fir, Douglas fir-sugar pine, and Douglas fir-fir-pine-spruce. Of these three subtypes, the first two represent the largest part of the Forest. The heaviest stands of timber occur on Lobster Creek, in T. 34 S., R. 13 W., and on the Illinois watershed in T. 40 and 41 S., R. 7 W.

The Douglas fir is usually of fair size and quality, as is the sugar pine on parts of the formation (head of Silver Creek, T. 34 S., R. 9 W.), averaging 3 to 4 feet in diameter, 60 feet clear and 100 to 120 feet merchantable in mature stands. Young growth of a wide range of age classes is plentiful in the stands on the above location, where sugar pine occurs almost as a pure subtype, except on the north slopes.

Chaparral Situation: Within the boundaries established for this formation the most continuous chaparral areas of the Forest are found (T. 37, 38, and 39 S., R. 9, 10, 11, and 12 W.). The chaparral species most common on these areas are those that are not particular in their demands for soil quality and moisture, and occupy intermediate positions in the scale of arrangement from these standpoints.

Management of the Chaparral Areas: The scheme for the reforestation of non-productive areas on the sandstone and limestone formations is applicable to those on the granite formations.

Porphyry Formation:

Location: The porphyry formation occupies a large portion of the east and central parts of the Forest and small portions at the south.

Soil: Loamy clay to gravelly clay are the common soil types. The iron oxides have given it a light-colored hue, which seems to be more common throughout the porphyry than elsewhere, and the more or less scattered nature of the undergrowth has not been conducive to the formation of a soil of high organic content. Repeated fires show their effects by reducing this soil to a stiff clay. Porphyry soils are second-class timber soils.

The Forest: The forest on porphyry generally belongs to a Douglas fir-pine, Douglas fir, and Douglas fir-fir subtypes, with the first two the most important. The Forest includes many areas that bear only scattering timber and which may be classed as woodland, while the commercial timber consists of sugar pine and yellow pine and Douglas fir. The former two species reach their best development on the porphyry formation on this Forest, and are of greater commercial importance than is the Douglas fir, except on some of the north slopes. The Forest appears to be undergoing a transition and the species an adjustment, or a step in the cycle in the rotation of species might more nearly state the facts. Throughout the woodland areas, where the stand of commercial timber is very light, is found a scattering stand of Douglas fir and pine, or often yellow pine alone, beneath which is an under story of California black and Oregon oaks and a ground cover of much young reproduction, principally Douglas fir, with a scattering of the pine. The next stand bids fair to be one of Douglas fir, thereby causing a change in the subtype. The cause of the change is not readily explained, although a large influence must have been exerted by fires that have burned throughout a large part of the Forest at one time or another.

Sugar and yellow pine appear to be best suited for porphyry locations, and should form the bulk of the commercial timber.

Chaparral Situation: The porphyry sites have many brush or chaparral areas. They are usually isolated from each other and cover no large continuous areas, but are common on many of the exposed slopes. The species most common are the ceanothus, California black and Oregon oaks, manzanita, and other species similar in their soil and moisture demands.

Management of the Chaparral Areas: On porphyry the plan for the reforestation of these areas calls for somewhat different treatment than on the preceding formations. Natural reproduction of the two pines is scarce, and it appears that to secure it a partial preparation of the soil is necessary, to which the seed spot method of sowing seems to be best suited. The seeds of both pines are eagerly sought by squirrels, chipmunks, and other small animals, which gather large quantities of seed

during each seed year, thereby preventing a dissemination of seed through other natural agencies. This is one of the causes of the lack of reproduction of sugar pine. Where sowing of sugar pine is to be carried on, or near sites where the brush is not of such density as to fully occupy the ground, and reproduction has a chance to come in naturally, these animals should be gotten rid of, either by poisoning or by placing a small local bounty on them, to be paid out of the Planting Allotment, subject to filing an affidavit with the Supervisor that the squirrels, etc., were caught within the limits of designated areas or have the game laws revised so that squirrels will not be protected, as is suggested by the State Forester of California in his recent report for 1910. The last suggestion, however, appears most impracticable. Before the seed of these pines matures these squirrels should be wiped out so that seed collecting can be carried on more cheaply and on proposed planting sites they should also be eradicated before sowing begins.

The seed spot method will be probably most largely used in the work of the reforestation of chaparral areas on the porphyry formation.

Serpentine Formation:

Location: The serpentine formation is found at the southern part of the Forest, where it covers a large area in T. 38, 39, 40, and 41 S., R. 9, 10, and 11 W., and on many other restricted areas throughout the Forest.

Soil: The soil on serpentine is usually a shallow sticky and stiff clay, especially deficient in organic matter. Much of the soil is composed of a reddish clay, well filled with small undecomposed granules of rock about the size of buckshot, and because of its strongly mineral character it is unsuited to support a heavy stand of vegetation.

The blending of serpentine soil with more favorable soils can be readily seen in the nature of the vegetation. Where the sandstone formation of the Winchuck gives way to the serpentine of the Nork Fork of Smith River this is very noticeable. On the one hand are seen the large ceanothus, salal, huckleberry, and rhododendron, and on the other are found dwarf manzanita, mountain juniper, and Prince's pine. Serpentine soils rank among the lowest in the scale of timber producers.

The Forest: The forest on serpentine usually consists of pine subtypes. On the best sites the subtypes are composed of sugar and yellow pine, incense cedar, and Douglas fir, while on the poorer locations, where fire has injured the stand, they consist of lodgepole, knobcone, and western white pine, with a sprinkling of sugar and yellow pines and Douglas fir. The timber varies much, but at best it is of poor, inferior quality. It is usually short, rough, and forms a light stand. The knob-

cone and lodgepole have especial value on sites of this nature, as they can prepare the soil for a more valuable forest crop. These sites will never carry heavy stands of timber, but they can eventually be made to support a merchantable stand of western white pine, Douglas fir, sugar and yellow pine, with a sprinkling of lodgepole. This, however, cannot be accomplished otherwise than by keeping out fire, and by carefully conserving the humus that may accumulate during the years or until it is found in sufficient quantities so that it can aid in the establishment of better forest conditions.

On the "Rough and Ready Barrens" (T. 40 and 41 S., R. 9 and 10 W.) the forest cover is of a pine subtype that has made a slow growth and makes up so light a stand as to be of little commercial importance. Scattered throughout are areas that are being restocked by almost pure stands of western white pine in pole stage, and suggests the idea of the eventual replacement of a large part of the stand with a subtype largely composed of western white pine.

Chaparral Situation: The serpentine has not been denuded by fire to such an extent as have some of the other formations, but where it has been the destruction has been complete and denudation has been greater than elsewhere. The "Barrens" at Snow Camp, in T. 37 S., R. 12 W., are now covered with a scattered vegetation consisting mainly of a prostrate manzanita, dwarf juniper, dwarf maple, live oak, with some reproduction of knobcone pine, and on such a site it is certain that little can be done to reëstablish a valuable stand of timber.

Management of the Chaparral Situation: Although no suggestions for the management of chaparral on serpentine formation, other than fire prevention, can be offered at this time, it is probable that more thorough study will devise some scheme of management applicable to these areas.

The following tabulation summarizes the foregoing descriptions of the different geological formations:

Soil types.	Forest sub-types.	Important chaparral species.	Classification of formation as timber soils.
		Sand and Limestone Formation	
Black loam Clay loam Loamy clay Gravelly clay	Douglas fir Douglas fir-redwood Douglas fir-Lawson-cypress Douglas fir-sugar pine Douglas fir-hemlock	Cascara, buckthorn, hazel, bitter-cherry, salal, Nuttall willow, thimbleberry, dogwood, arrow-wood, sticky laurel (*ceanothus*), sadler oak, Oregon oak, rhododendron, huckleberry	First and second class
		Granite Formation	
Loamy clay Gravelly clay Stiff clay	Douglas fir Douglas fir-sugar pine and Douglas fir-fir-pine	Tan oak, rhododendron, sadler oak, dogwood, chinquapin, huckleberry, manzanita, madrona, live oak, sticky laurel, salal	Second and third class
		Porphyry Formation	
Loamy clay Gravelly clay Stiff clay	Douglas fir Douglas fir-pine Douglas fir-fir	Oregon and California buckbrush, buckthorn oaks, sticky laurel, mountain mahogany, Nuttall willow, rhododendron, dogwood, chinquapin, madrona, arrow-wood, manzanita	Second and third class
		Serpentine Formation	
Gravelly clay	Douglas fir-pine Pine	Manzanita, live oak, serviceberry, dwarf juniper, dwarf maple, prince's pine	Poorest class of forest soils

Conclusions

The natural conditions are favorable for tree growth on the greater per cent of the chaparral areas by nature of the underlying formation, soil, altitude, slope, and annual precipitation. They can be restocked by planting and sowing and by the elimination of the great injury done to these sites by fire. The whole situation resolves itself into the question of what are we going to do about it.

On the Siskiyou we should have equipment to aid in collecting and

storing seed; we should study out different methods of collecting seed, so that they can be secured at the lowest possible cost; we should combat all small animals that use a large part of the seed crop of certain species for their food supply in those sections where we wish to collect seed, or where planting is to be carried on; we should secure reproduction by natural or semi-natural methods, where possible, as burning over a strip of chaparral adjoining seed trees; and we should start in by sowing from 800 to 1,000 acres annually. To carry on the work on this scale would require that our annual allotment should be $5,000 at least. Could we carry on the work on such a scale, or on a larger scale, we would soon convince the public that the chaparral areas were capable of something better than to grow brush to be burned over annually; we could help to create a stronger public sentiment against Forest fires, and we would be taking a step forward to bring the Forest to a higher state of production.

Silvical Notes: Distribution of Species.

Western Hemlock. Tsuga heterophylla (Raf.) Sargent. Common on the south fork of the Coquille River and along main streams in the northwestern part of the Forest, north of Rogue River. Also found along the Rogue-Illinois divide from Howard Creek (T. 34 S., R. 8 W.) to the mouth of the Illinois, in the western part of T. 35 S., R. 11 W., and on the Indigo-Silver divide, in T. 35 S., R. 9 W.

Weeping Spruce. Picea breweri, Watson. The complete range of this species is believed to be as follows: At the head of the West Fork of the East Fork of the Illinois River, and near the head of the East Fork of the East Fork, in T. 20 N., R. 5 and 6 E., H. M.; at the head of Deer and Sucker Creeks, in T. 38, 40, and 41 S., R. 6 W.; on the Chetco-Illinois divide at the heads of Josephine, Canyon, Fidler's Gulch, Carters, Babyfoot, and Rancherie Creeks; on the Illinois-Rogue divide, in section 34 (approx.); on Silver Creek, in sections 20 and 21 (approx.); on divide between Middle and South Silver Creek, and in sections 5, 7, and 8, on Indigo-Silver Creek divide, T. 35 S., R. 9 W., and at Game Lake and at the head of Lawson Creek, near Snow Camp, in sections 23 and 24, T. 36 S., R. 12 W., and sections 7, T. 37 S., R. 13 W.

This species occurs at an elevation of from 3,000 feet upward. Largest specimen measured was 26 inches in diameter and 100 feet high.

Sadler Oak. Quercus sadleriana, R. Brown Compst. Common along summit of Rogue-Illinois divide; also on Illinois Chetco divide. Usually occurs around 4,000 feet and above, and is found in both a chaparral and undergrowth.

Western White Pine. Pinus monticola, Dougl. Common on poor sites at high elevations from Rogue River south to the California line.

Dwarf Maple. Acer glabrum, Torrey. Common on high rocky ridges around Bear Camp, in the eastern part of T. 34 S., R. 10 W.

Redwood. Sequoia sempervirens (Lamo), Endlicher. This species is found on lower Winchuck, on both sides of the river, in T. 41 S., R. 12 W., with the largest grove occurring on Bear Creek in 11, 13, and 14 (part of which is unsurveyed and unalienated). In T. 40 S., R. 12 W., it is found on the east slope of Wheeler Creek, in sections 28 and 33, and on the East Fork of Wheeler Creek, in sections 9, 10, and 16. Outside the Forest, it is found in sections 11, 12, 13, and 14, T. 40 S., R. 13 W., on the west side of the Chetco River, which is the northern limit of its range of distribution.

USE OF SOIL FUNGICIDES TO PREVENT DAMPING-OFF OF CONIFEROUS SEEDLINGS [a]

BY CARL HARTLEY

I wish to report some interesting phases of work on the damping-off disease of pine seedlings, which I have conducted with the assistance of Miss D. E. Ingram, Mr. R. D. Rands, and others at the Halsey Nursery in the sand hills of Nebraska. The days there are hot and dry, the nights cool, with heavy dew. The soil is a very fine sand, containing considerable humus, enough in the upper 10 inches so that its non-available water coefficient is 4.1 grams per 100 grams of dry soil, while the subsoil has a non-available coefficient of 1.9 grams per 100 grams of dry soil. [b] The disease is mostly caused by *Pythium debaryanum* Hesse, though *Rhizoctonia* sp. and *Fusarium* sp. cause some damage. *Pythium* and *Rhizoctonia* kill germinating seed as well as seedlings that have come through the ground.

Thirteen chemical substances and seven combinations of substances have been used; light has been thrown on the working of these substances by parallel tests of pasteurized soil, the attempt being made to avoid in the heated soil the profound chemical and biological changes produced by complete sterilization. From the first, chemical injury to the seedlings has been encountered. It is not safe to apply fungicides to seed beds after germination. When fungicides are applied at the time of seed sowing or earlier, in strength sufficient to be effective, there is still chance of injury to the pines at time of germination, and formalin and mercuric chloride can kill seed which is still dormant. It was found, however, that proper watering would avert injury from acids.

Sulfuric acid, which proved to be the most satisfactory fungicide of those tested, does not injure dormant seed in any ordinary concentration. Most of the acid probably breaks down soon after application, but if at any time during germination evaporation greatly exceeds the water applied to the beds the consequent capillary rise of soil solution to the surface results in concentration of the remaining acid at the surface, and the growing apices of the radicles which are still in the upper half inch of

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a Paper read before American Phytopathological Society, December, 1911.

b Determined by water equivalent method, through the courtesy of Dr. L. J. Briggs.

soil are killed. While this stops extension of the root, absorption is still possible except in cases of extreme injury. If the surface soil is kept moist around the short root, the stem and cotyledons push up through the soil and grow normally, sometimes for two weeks; by this time adventitious roots may develop just above the original point of injury and the seedling will entirely recover. In cases of injury just as the radicle starts, the root is only about one-fourth of an inch down in the soil, and even if sufficient absorbing surface is left alive, the seedling after it comes through the soil falls over and dies purely for lack of mechanical support.

The method I have developed to prevent this acid injury is simply to water the beds lightly twice a day during the germination period. The watering is done twice daily, because tests indicate that if double the amount of water is applied, but only once per day, there is more danger of drying out the immediate surface between waterings, with consequent concentration of the acids in the surface soil and injury to the growing apex of the radicle of the germinating seeds. The injury to seedlings from acid applied before seeding seems analogous to the alkali injury to field crops, which occurs typically only in territory where evaporation is rapid; it is therefore to be presumed that eastern nurseries, with their more humid climate, would have less trouble from acid injury. My explanation of the exact way in which acid injury takes place is, of course, somewhat hypothetical, but the value of frequent watering in preventing such acid injury has been demonstrated time after time. Attempts to prevent acid injury by leaching were only partly successful.

My experience indicates that commercial sulfuric acid will kill *Pythium* and *Rhizoctonia* if three-sixteenths of a fluid ounce is used per square foot of soil surface, while one-eighth of an ounce per square foot is not sufficient. Less experimental evidence indicates that commercial hydrochloric acid is a little more than one-fourth as effective as sulfuric, volume for volume, and that commercial nitric acid is less than one-fourth as effective as sulfuric. The performance of hydrochloric acid as compared with sulfuric roughly accords with the statement of Kahlenberg & True [c] that these acids are equally toxic where the hydrogen ions are equally concentrated. Nitric acid is weaker than this theory would lead one to expect, apparently because it combines more quickly after it enters the soil.

Formalin is at least half as efficient as sulfuric acid, volume for volume—that is, three-eighths of an ounce per square foot is sufficient to

[c] Kahlenberg & True, Botanical Gazette, 22: 81-124 (1896).

kill *Pythium* and *Rhizoctonia*. Probably three-fourths of this amount would be sufficient. With mercuric chloride one-sixteenth of an ounce per square foot was found efficient. With zinc chloride nine thirty-seconds of an ounce was sufficient. One-fourth of an ounce per square foot of copper sulfate crystals did not seem sufficient. Lime-sulfur solution was less than one-fifth as efficient as sulfuric acid. Stronger ammonia water at the rate of one-half of an ounce per square foot seemed to have some value. Air-slaked lime, one-half of an ounce per square foot, has no value, and three-fourths of an ounce or more has resulted in the death of *Pinus divaricata* seedlings.

A complicating factor has been the rapid reinfection of treated soil where it is not protected. If soil is pasteurized by heat, treated with weak formalin, or is sterilized with acid or toxic salts and later treated with small quantities of lime to take up the poison, more killing by *Pythium* actually occurs in some cases than on soil which has not been treated at all. Inoculations with *Pythium* on sterilized soil have been uniformly successful, while inoculations on unsterilized soil usually fail. There is thus every reason to believe that competition of other soil micro-organisms is the greatest factor in limiting the damage from *Pythium* in untreated beds. A successful treatment must first kill the parasites, and then must leave a residue in the soil which will prevent reinfection with the parasite for the next three or four weeks and yet not injure the seedlings. Sulfuric acid usually does this if followed by proper watering. Hydrochloric acid prevents reinfection, but seems more likely to hurt the seedlings. Formalin and nitric acid do not prevent reinfection quite as well as sulfuric acid, and soluble salts seem to have much less ability to protect against reinfection. Because of its nominal cost and its convenience, as well as its efficiency, I consider sulfuric acid to be the best fungicide for preventing damping-off at this sand-hill nursery.

The treatment which I have recommended for use at this nursery consists of three-sixteenths of a fluid ounce of commercial sulfuric acid per square foot, applied to the beds in aqueous solution at the time of seed sowing, the beds to be watered sufficiently during the germinating period to prevent acid injury. In nine separate series of tests, conducted at different times during two different seasons and in different parts of the nursery, with three species of pines, the following results have been obtained:

1. The germination obtained on the seven plots on which germination counts were made averaged approximately 65 per cent greater than in the nearest control plots.

2. Loss from damping-off on these seven plots on which full counts were made averaged less than 45 per cent of that on the control plots.

3. The final stand obtained on all of the plots in these series was over four and a half times as great as on the control plots.

Of course, no such marked results will be obtained during seasons when the damage from the parasites is less than usual.

An additional result of this treatment which commends it to the nurseryman is that it kills most of the weeds in the seed beds. The advantage gained in this way will in some cases at least be sufficient to pay for the entire cost of the treatment.

I cannot predict a great future for sulfuric acid as a general soil fungicide. In limestone soils it will probably fail to prevent reinfection. In my own work angiosperms as a class have been much more susceptible to injury by it than are the pine seedlings. But I believe that at the western sand-hill nursery, where I worked, sulfuric acid will solve the problem of preventing the serious inroads of *Pythium* in pine seed beds.

RESULTS OF CUTTINGS ON THE MINNESOTA NATIONAL FOREST UNDER THE MORRIS ACT OF 1902

RAPHAEL ZON

(Contributed)

The cuttings on the Minnesota National Forest are confined exclusively to white and Norway pines. Under the Morris Act of 1902, 5 per cent in volume of all standing timber is required to be left as seed trees.* The first cutting under this act began in the fall of 1904. The oldest cuttings, therefore, are a little over five years. Since the cutting began there was recorded only one good seed year for both white and Norway pines, namely, in the fall of 1904. In 1907 there was a slight seed crop of white pine. The number of seed trees left above 10 inches in diameter, breast high, which represent 5 per cent of the volume of the stand. average on sections where the stand was thickest about one and a half trees to the acre, while on the poorly stocked sections an average of about one-tenth of a tree to an acre is not infrequent. These seed trees are not distributed uniformly over the section, but are irregularly scattered. There are acres on which no trees are left at all, while on others there are several. The old stands of Norway pine and of white pine are, as a rule, fairly open, especially the white pine stands, thus allowing light to the ground and enabling some herbaceous vegetation to start even before the cutting of the old timber began. This is especially true of the white pine stands in which the fresher and better soil is capable of supporting a much denser and varied vegetation than the poorer soil on which the Norway pine is grown. In many instances there is a fairly good reproduction of Norway pine or white pine under the shelter of the old trees.

Norway Pine Cuttings of 1904

Since the cuttings are all of comparatively recent date, the areas which could furnish more or less decisive results are those cut in the fall of 1904. An examination of the cut-over areas on the Forest was

*An amendment to this act (May, 1908) provides for leaving as much as 10 per cent in volume of all standing timber. No cuttings, however, were examined which came under the operation of this amendment.

begun with the cuttings of 1904. Such cuttings were examined in section 16 on the east shore of Cass Lake. Unfortunately these areas were badly burned in 1908, and are, therefore, of little value in determining the effect which the methods of cutting under the Morris Act have had on the natural reproduction of white pine and Norway pine. The old cuttings on section 23, north and south of the track of the Great Northern Railway, however, are most instructive. They have a very good natural reproduction and present a variety of conditions which bring out more or less clearly the advantages and disadvantages of the methods of silvicultural treatment now adopted on the Minnesota National Forest. The cutting of 1904, on section 23, south of the railroad track, was burned over in 1904, soon after logging, at the time the brush was burned. The land is Norway pine land, hence poor in quality, and the herbaceous vegetation and the shrubs are not thick. The reproduction is good and ranges in age from two to five years. The fire that occurred late in the spring burned heavily into the ground, and has been beneficial in clearing the ground of the herbaceous vegetation and the bushes which covered the ground. This elimination of weeds and poor vegetation on the sandy soil of the Norway pine land has kept the soil comparatively free of herbaceous vegetation and afforded good conditions for the seed of Norway pine to lodge in the ground and come up, although the seed crop years after 1904 were very scanty and poor.

North of the track there is an excellent Norway pine reproduction which dates from the time of the first logging. This area was also burned over in 1904, but early in the spring, when the frost was still in the ground and no damage was done to the reproduction which had then just started. The land is also Norway pine land, with comparatively thin vegetation, and the reproduction is mostly five years old, which shows that it started in the year of the heavy seed crop, in 1904, and since no fires have burned over this ground since 1904, it has not been interfered with.

The results obtained on these two areas indicate the conditions which are favorable to a good natural reproduction of Norway pine. These conditions consist of a good seed year at the time of cutting and of ground comparatively free from weeds. On Norway pine land vegetation is usually not very thick, and if at the time of logging there happens to be a good seed year and the ground is burned over, the seed of Norway pine finds favorable conditions for germinating, starting up, and getting ahead of vegetation that will spring up later. Should, however, the logging, which is practically clean cutting, occur at a time when there is no seed year or a very poor seed year, the unshaded ground becomes quickly

covered with vegetation. The latter, in many cases, takes complete possession of the ground and prevents for many years the coming in of Norway pine. The leaving of only 5 per cent of the volume of the stand means practically clean cutting. One or, at the most, two trees to the acre left on an average for a section cannot, of course, afford any shade to the ground, and the latter becomes quickly grown over with other vegetation unless the pine seed gets into the ground first.

White Pine Cuttings

This is strikingly apparent on white pine land, which, being generally of a better quality, supports a heavier herbaceous vegetation than the poor sandy land of the Norway and jack pines. On the oldest white pine cuttings on section 27 the bushes and herbaceous vegetation form almost an impenetrable undergrowth. White pine seedlings that were found on these areas mostly antedate the time of logging, which shows that they started when the old stand, by offering some protection to the ground, kept out the undergrowth from completely occupying the ground. The logging on section 27 was in a windfall; the white pine trees were dead and leaning at the time of logging, and afforded, of course, an inadequate protection to the ground, and there was some undergrowth prior to logging, but it became much thicker and heavier after logging. The occasional seedling or group of seedlings that are found on this area are mostly in places where herbaceous vegetation is lacking or under the protection of aspen, willow, or some other taller bushes under which the ground is free of weeds.

The appearance of aspens, hazel bushes, dogwood, raspberry bushes, ferns, and herbaceous plants has been noticed on nearly all cuttings that were made during poor seed years, and to a much greater extent on the better white pine land. On the poor, sandy Norway pine land vegetation was found to be less thick, and therefore interfered less with pine reproduction. This explains the commonly accepted view that Norway pine cuttings more readily reproduce themselves than the white pine cuttings. This has been clearly demonstrated in the cuttings of 1905 on sections 28, 29, 32, 33, and 20.

Conclusions

The examination of the cut-over areas on this Forest shows that while there are areas with a fairly good reproduction, especially of Norway pine on Norway pine land, this was due to accidental combination of

circumstances, rather than to the method of silvicultural treatment now adopted on the Forest. A good seed year at the time of logging, followed the same year by a light ground fire, or even without a fire, when the soil is stirred up by the skidding of logs, creates conditions favorable for a good reproduction of the pine. When any of these conditions are lacking the reproduction is uncertain, and is apt to be a failure rather than a success.

I wish to emphasize that in speaking of reproduction I do not mean a few seedlings, or even a few hundred seedlings, to the acre. I mean a reproduction which is sufficient to produce a hundred years hence a merchantable stand of timber. Allowing for the natural thinning out of the young growth, there must be at least between fifteen hundred and two thousand seedlings to the acre in order to produce a merchantable stand at the time of maturity. A few hundred seedlings per acre may be capable of growing up and producing a large amount of seed, but cannot produce a merchantable stand of timber. On any forest, managed under some kind of a working plan in which natural reproduction is the adopted method of regeneration of the cut-over areas, a certain time is allotted during which there must be a complete regeneration of the old cuttings. This period may vary from five to ten, or even twenty, years; but if during this regenerative period no natural reproduction takes place, or the reproduction is poor and not capable of producing a merchantable stand, the natural reproduction must be recognized as a failure. If the cut-over area is to be reproduced at all, artificial means must be resorted to.

On the Minnesota National Forest the logging is carried on every year without any reference to the presence or absence of a good seed crop. The burning over of the ground at the time of burning the brush, as it happened on section 28, is merely an accident, and since the brush is now burnt during the winter a repetition of such an accident is less apt to occur. With the constantly growing efficiency in fire patrol and fire prevention by means of fire lines along the railroad tracks, etc., fire as a means of clearing the ground of vegetation will play a less important part. Under such conditions the present method of silvicultural treatment will tend to result in the cut-over areas becoming grown over with rank vegetation, which will check the coming in of the pine for many years to come. This will be especially true on the white pine land, which is capable of supporting a much more varied and thicker vegetation than the poor sandy lands of Norway and jack pines. On areas which will be logged over during the years of a heavy seed crop,

the cut-over areas may quickly come up to pine again, but on areas which will be logged over during years of poor seed crops or no seed at all, the reproduction on the cuttings will in most cases be delayed for many decades. Nature, if left alone, will gradually bring back the original forest on the land most suitable for it, but it will take decades to do this.

The facts observed necessarily force one to the conclusion that the ideal way to handle the white and Norway pine on this Forest would be not to cut them clean, as is done at present, but to cut them off in two successive loggings, separated by an interval of from 15 to 20 years. In the first logging there should be removed only so many trees as will encourage the development of larger crowns on the remaining trees and make them produce a larger amount of seed. In the first logging the forest should not be opened so as to encourage the coming up of raspberry and hazelnut bushes, willows, or of any other herbaceous plants. With the forest slightly open, yet the ground fairly shaded, and therefore comparatively free of herbaceous vegetation, and with a large amount of seed produced by the remaining trees, it is natural to expect that there will spring up an undergrowth of white and Norway pine under the shelter of the mother trees. After this pine undergrowth is well established and has reached a height of from 2 to 3 feet, the remaining trees should be removed in the second logging and the reproduction freed of shade. That this method is adapted to both Norway and white pine stands, but especially to the white pine stands, is clearly shown by the presence of a fairly good reproduction of white and Norway pine under the shelter of the old trees in stands which had not yet been logged. Moreover, the white pine seedlings, as a matter of fact, need protection for at least the first four or five years of their life by the old trees, and the same is true, though perhaps to a lesser degree, of the Norway pine.

This is, of course, the ideal which, under present economic conditions and the comparative low stand of timber per acre, may not be attainable.

Since the removal of the present mature stands in two loggings may not be advisable for economic reasons, the logging of the timber should at least be confined either to years of good seed crops or the cutting, which must be made when no seed is produced, and for this reason become overgrown with vegetation, should be cleared of the latter by fire or any other artificial means in the year preceding a good seed crop. The removal of vegetation from the old cuttings prior to a good seed year makes conditions favorable for natural reproduction. It may seem paradoxical, yet it seems true that fire, which is largely responsible for the deterioration of our forests, in the hands of a forester, if intelligently applied, may become the means of their recovery.

These conclusions are based only on a few days' observation at a time when the thick undergrowth might have prevented seeing a much larger number of pine seedlings, and therefore lead to more pessimistic conclusion. A study of these cuttings in September or early in the spring, when the deciduous vegetation is bare, especially in connection with a detailed history of the original stand, number of trees left, logging, etc., would furnish a more solid foundation for conclusions.

SILVICULTURAL SYSTEMS OF MANAGEMENT FOR CENTRAL ROCKY MOUNTAIN FORESTS

CARLOS G. BATES

(Contributed)

The following statement of the systems of management applicable to the various species found in the central Rocky Mountains is merely a survey of present procedures, and is not in any sense final.

Management of the National Forests at present is very largely directed with a view to building up the lumber business, and at the same time improving the character of the virgin forests. It is impossible to say how far we are from the ideal system of management for any of the important species, but it is certain that the ideal cannot be reached until economic conditions have greatly improved, and until, by a gradual process, the virgin forest has been transformed into a normally stocked forest. The methods which are outlined herewith and the ideas which are expressed are open to wide discussion. Such discussion, however, must, to be of value, be based upon a familiarity with the local conditions which control and are likely to control, for years to come, the management of the forests.

While timber sales must be handled under the conditions described above, it is quite possible at this stage to carry out certain theoretical and ideal systems of management on a very small scale. This is being done already on several forests where permanent sample plots have been laid out, and these, together with all such valid conclusions as can be obtained from general observations of cut-over areas, are certain to form the basis for future silvicultural management.

MANAGEMENT OF ENGELMANN SPRUCE

Characteristics of the Species

Engelmann spruce is, above all, a tolerant tree. It demands a great deal of moisture, and hence is favored by cool situations with a short growing season. These are to be found either in pockets or on north slopes at middle altitudes, or on any but the most exposed slopes at higher altitudes. The tree usually produces seed in some quantity every year, but the seedlings are not favored by a thick humus, which is

usually found in dense Engelmann spruce stands. A moderate amount of light, which permits the gradual decomposition of the humus and an exposure of the mineral soil, induces reproduction of this species. Observations on sample areas have shown that where Engelmann spruce and alpine fir were both present in the original stand the reproduction of Engelmann predominates with a crown density of less than .5, while alpine fir reproduction predominates with a crown density of more than .5; hence it may be said that spruce is less tolerant than alpine fir. Spruce is very frost-hardy, because by habit and environment it is induced to commence growth only when the season is well advanced. Growth is stopped early in the fall.

Characteristics of the Engelmann Type

Engelmann spruce almost invariably occurs in uneven-aged stands. All sizes are represented, the average maximum being about 30″ D. B. H. Trees often remain sound until they attain an age of 300 to 400 years. Merchantable size, however, which may be set at from 14 to 16 inches D. B. H. for saw timber, is usually reached at about the age of 150 years, or at high altitudes and in very cool situations at 200 years. One hundred and fifty years may be placed as the rotation period for Engelmann spruce in the average situation. The common associates at lower elevations are alpine fir in the moist situations and lodgepole in the drier situations.

The stands are dense unless they have been damaged by fire, which is of rare occurrence in this type on account of the constantly moist condition of the ground. On account of their rare occurrence, fires are usually fierce in the spruce type and fatal to all the trees. Both at the higher elevations and in the pockets where Engelmann spruce occurs at lower elevations, the snow is retained until mid-summer, and the season when fires are possible is very short. The stands frequently run from 10,000 to 15,000 feet B. M. of merchantable timber, with 20 to 30 trees per acre of merchantable size. A cut of 5,000 feet B. M. per acre is, in most cases, necessary to satisfy the purchaser, since the timber usually occurs in inaccesible places where logging is expensive.

The selection system only is applicable to Engelmann spruce because of the uneven-aged character of the stand. The system is feasible, and probably will undergo little alteration, because the tree is tolerant and is quite certain to reproduce well. The following case, taken from the Leadville Forest, shows what is ordinarily done in a sale of Engelmann spruce:

Original stand: 11,000 feet B. M. per acre; 80 trees, 6″ or over D. B. H.; 40 saplings per acre; 100 seedlings per acre.

Amount cut: 6,000 feet B. M. per acre, divided between 30 trees with an average diameter of about 20 inches.

The marking was entirely by the selection system, with a view to removing as many mature, overmature, and defective trees as possible. The brush was lopped and scattered. The advantages of this system of cutting Engelmann spruce are:

1. The diameter limit is not fixed, and the cutting of alpine fir seed trees, wherever they occur, is made possible.
2. The opening is sufficient to induce Engelmann spruce reproduction rather than alpine fir, should any seed trees of the latter be left.
3. Slow-growing trees are removed, and the stand is left in condition to make rapid volume increment.
4. A good number of trees which are of merchantable size, or will soon be, are left on the ground to insure a seed crop, and a second cutting within a reasonable period, say 20 years.
5. The soil cover is not sufficiently exposed to induce detrimental drying out or to reduce the value of the forest for protective purposes.
6. The operator is not put to the unnecessary expense of piling brush, because the fire danger is not sufficient to warrant it; hence a higher stumpage price is secured.

Management of Douglas Fir

Characteristics of the Species

Douglas fir is moderately tolerant and only moderately exacting as to the amount of moisture in the soil. The tree grows moderately well on exposed south slopes where moisture is deficient. Reproduction, however, occurs in such situations only where the surface moisture is conserved by a nurse, such as aspen or shrubbery. The growth of Douglas fir in the Rocky Mountains does not compare with that of the Pacific Coast form, a diameter of 12 inches being seldom obtained in less than 100 years. The quality of the wood, so far as toughness and durability are concerned, is somewhat superior to that of the more rapid growing coast form. It is highly prized for railroad ties, telephone poles, and fence posts, and somewhat used for dimension stuff, but never yields the large dimensions which are obtained on the coast and is seldom used for boards.

Characteristics of the Type

Douglas fir seldom occurs in pure stands. It is a tree of middle altitudes. Yellow pine invades the type on south slopes and other exposed situations from the lower edge, while Engelmann spruce invades the type on all of the more moist and favorable situations from the upper edge. Where found in mixture with Engelmann spruce, Douglas fir, if growing thriftily, is always to be favored in the management, on account of the superior quality of its wood. In mixture with yellow pine the preference of species is very doubtful, and must, in all cases, be determined by the local quality of the trees and the local demands for the two diameters. Good stands of Douglas fir are seldom of great extent, and hence in any locality the average stand per acre is seldom over 2,000 or 3,000 feet B. M. In many cases it would not be possible to cut 500 feet B. M. per acre, if all of the merchantable trees were taken.

On account of the great value of watershed protection at the altitudes where Douglas fir occurs and where the snow at best melts all too rapidly in the spring, Douglas fir in the Rocky Mountains may never be cut clear, even though this were best from the silvicultural standpoint. Many Douglas fir areas must be left practically undisturbed for protective purposes.

The following case shows the character of a cutting on the Rio Grande Forest in a mixed stand of yellow pine and Douglas fir:

Original stand: 3,000 feet B. M. per acre, of which about two-thirds was yellow pine; 15 trees, over 6″ in diameter, per acre; 25 saplings per acre; 15 seedlings per acre.

Amount cut: Average diameter of trees cut: Yellow pine, 23″; Douglas fir, 25″. Average height both species, 65′. Average number trees per acre: 2.7 yellow pine; 1.3 Douglas fir. Average volume per acre obtained: 1,070 feet B. M. yellow pine; 530 feet B. M. Douglas fir.

Amount left: About 1,100 feet B. M., mostly pine.

The effect of such a cutting as this upon reproduction is very doubtful. If aspen is present as an understudy, as it so often is with Douglas fir, it is probable that reproduction will gradually appear, but it certainly is not assisted by the removal of any trees from a stand which was originally so light. The only strong argument for a sale in this class of timber is that if not removed the four trees per acre, with a diameter of 24″, would soon deteriorate and be lost.

Management of Yellow Pine

There are two distinct classes of yellow pine forests in District 2. The most common type is that which is found in foothills and up to

elevations of approximately 9,000 feet, where the rainfall seldom exceeds 15" per annum. At these low elevations a loose, gravelly soil is common, but the tree is also often found on loamy soils above sandstone or conglomerate. In these situations yellow pine invariably forms an open stand, with from 25 to 30 trees per acre as a maximum. Often in this class of yellow pine timber the trees are large and yield as much as 2,000 or 3,000 feet B. M. in rare cases.

The other class of yellow pine is that found in the southern portion of the Black Hills, where the rainfall is from 25 to 30 inches per annum, and in the Wet mountain division of the San Isabel Forest, where the rainfall is almost or fully as great. In this class of yellow pine the trees are usually slow growing, attain a maximum diameter of about 25", and occur in stands of at least 200 trees per acre. The reason for the occurrence of yellow pine in this locality, on ground belonging by reason of moisture to Douglas fir, has never been fully explained.

Yellow pine is characteristically intolerant and demands a large amount of sunshine and a long growing season. The most rapid growth occurs where these factors are combined with a good moisture supply. The extremely slow growth of yellow pine on the San Isabel and in the Black Hills is explained by the large amount of moisture which induces dense stands of reproduction and competition between the trees in early life, retarding the growth of all individuals alike. In the Black Hills the merchantable diameter, 16 to 17 inches D. B. H., is usually attained in about 200 years. In the first class of yellow pine—that is, the stands which are characteristically open and contain a small number of trees per acre—reproduction is extremely difficult to obtain on account of the low moisture content of the soil and the dryness of the spring season. The protective value of such forests is at best very little, since the snow, regardless of the tree growth, is melted early in the spring and is of such small volume that most of the moisture is taken into the loose soil. Consequently, cutting is done with only a regard for leaving seed trees, the seed from which, after severe logging or some artificial scratching of the soil, may find a suitable bed. In this connection it is well to mention that the strongest factor in preventing yellow pine reproduction is undoubtedly the sod which covers the ground even before cutting is done, and which has a preëmption on all of the surface moisture.

Five or ten good trees per acre are considered sufficient for seeding purposes, but since the species usually occurs in groups of somewhat even age, it is frequently desirable to leave in a group a larger number than this of thrifty young trees, taking all of the larger trees which are scat-

tered between the groups and which are ripe for the axe. Such a cutting as this has recently been done on the San Juan National Forest:

Original stand: 4,500 feet B. M. per acre; 25 trees over 6″ D. B. H.; 8 saplings per acre; 6 seedlings per acre.

Amount cut: 3,255 feet per acre; number of trees, 8½ per acre; average diameter trees cut, 22″.

The *advantage* of a cutting of this kind in yellow pine is that the logging is severe enough to considerably stir the soil, and some reproduction may be invited. The danger from fire is removed by piling and burning the brush. The mature and over-mature timber is disposed of before it can deteriorate.

The great *disadvantage* of this cutting is that reproduction is not assured and that artificial means may necessarily be resorted to to fill up the spaces left by the removal of the large trees. Such treatment would probably consist simply of stirring the ground or in some way destroying the heavy sod. The disposal of the brush by scattering it evenly over the areas on the leeward sides of the trees, where seed is most likely to fall, has been found helpful to reproduction by conserving the surface moisture and by preventing frost damage to seedlings which spring up in the late summer. In most cases this measure appears to be impracticable because of the great danger from fire, and it cannot be generally advocated until public sentiment is thoroughly in disfavor of forest fires.

With yellow-pine stands, such as occur on the Black Hills National Forests, the volume per acre is little more than is found elsewhere, and has been much longer in accruing. From stands of 6,000 feet B. M. per acre are usually cut at least 4,000 feet, leaving a few immature trees in wind-firm groups for seeding purposes. Since, in most cases, there is already a good stand of reproduction and of saplings on the ground, the seed trees are simply left as a precaution against the loss by fire which may occur soon after the cutting. If the area is not visited by fire the groups of seed trees may well be removed in from 10 to 20 years, and the volume left in them is sufficient to warrant cutting over the area within that period.

Management of Lodgepole Pine

Although lodgepole pine is individually a secondary tree and a kind of forest weed, its commercial importance in District 2 must not be underestimated, since it occupies probably more extensive areas than any other single species. This is commonly thought to be a result of

fires, and the lodgepole pine type has been described by some as a temporary type. However, in many localities lodgepole has come to stay, and could not possibly be replaced by any other means than artificial reforestation.

Characteristics of the Species

The demands for moisture by lodgepole pine are second only to those of Engelmann spruce, and the tree is commonly found in the better situations which might be occupied by Douglas fir and in the lower reaches of the altitudinal range of Engelmann spruce. The tree is considerably less tolerant than Engelmann spruce, as shown by the fact that it may gradually be replaced by spruce, where the two occur in mixture. The rate of growth is uniformly slow, particularly on account of the short growing season at the elevations where lodgepole occurs, but more on account of the dense, crowded condition of the stands in which lodgepole is found. It is no uncommon thing to find trees 200 years old which are not over 12″ in diameter. The average 11″ tree, which is big enough to produce ties, is probably about 150 years old.

Characteristics of the Stand

While it does not seem possible that a tree so intolerant as lodgepole can grow in a natural selection or all-aged stand, yet the stands of lodgepole are never of even size. Most of the stands, it may safely be said, have come in within a few years after a fire, and of the original seedlings which may have numbered as many as 10,000 to the acre, there have been some natural leaders which have developed much more rapidly than others. These are the dominant trees of the present stands, and below them are trees in all stages of suppression. In such stands a tree of 3″ diameter may be fully as old as a tree of 12″ diameter. Also, in any area of considerable extent which appears to have been covered by fire, there are certain to be small groups of trees which were left from the original stand. At a certain stage these are found as large, limby, stag-headed trees, usually defective at the base, surrounded by trees in the pole stage. At a later stage, the spaces occupied by the large trees may be vacant or occupied by reproduction, while the stand which came in after a fire has attained the size of standards.

A very important characteristic of lodgepole stands is the inflammable character of the ground litter, probably because the stands are so dense that snow falls evenly in the forest and does not pack or drift; it disappears quite early in the spring at the ordinary elevation where the tree is found, and during the summer the litter may become very

inflammable. While the leaf litter is usually not deep, the fire danger is commonly added to by the presence of a great number of stems of suppressed trees which have fallen.

The best stands of lodgepole pine run from 10,000 to 25,000 feet B. M. of merchantable saw stuff, ties and mine props, together with several thousand feet of dead material which may be thrown into any one of these classes.

Improvement Thinning

Owing to the prevalence of the stand conditions which have been described above, the present problem in the silvicultural management of lodgepole pine is to remove the rapidly deteriorating dead and overmature trees. Since the stands may run from 200 to 500 trees per acre, with an average diameter of 12-8″, it may be seen that such an improvement thinning may be quite heavy without reducing the growing stock to a dangerous point. The greatest care, however, must be used in almost every situation where lodgepole has grown in a dense stand, not to weaken the resistance of the stand to the effect of wind. Many cuttings, which have been very desirable for the improvement of the stand, have been entirely thwarted in their purpose by windfalls following cutting. Wind may even uproot stands which have not been touched by the axe, so that it is almost impossible to predict, in cutting, how much can safely be taken. The point which deserves the greatest consideration is, under what soil conditions have the trees grown and what is the development of the roots? With an intelligent knowledge of these facts much more heavy cutting could be done in some localities than has been done, while in other localities the restrictions should be closer than would operate to the best interest of the lumbermen. The following is a case of improvement thinning in a stand in which the dominant trees are of log and tie size, and in a region where the danger from windfall is great. The example is taken from southern Wyoming:

Original stand: Merchantable material, 13,400 feet B. M. per acre; 310 trees above 6″ D. B. H.; 178 saplings per acre; 15 seedlings per acre.

Amount cut: 4,700 feet B. M. merchantable timber; 40 trees per acre; average diameter, 12″; average height, 55′.

It must be seen from these figures that the improvement cutting in lodgepole, while taking only about 12 per cent of the total number of trees per acre, is removing over 35 per cent of the total volume, and this almost wholly in the form of trees which would rapidly deteriorate

if left. The cutting is done mainly for ties, but also utilizes all material better suited for saw stuff and all tops which will make mine props.

Selection System

It is almost unnecessary to say that in the management of lodgepole the point has not yet been reached where the best silvicultural system can be applied without detriment, not only to the Government in the loss of timber, but also to the purchaser in forcing upon him material which he cannot dispose of, or too little material to make his operations profitable. Improvement thinnings are necessary at present, to avoid the damage above described, which would result in loss to both parties. However, a great many attempts have already been made to apply a final cutting system to lodgepole which would lead at once to the best condition of the forest. It has been supposed by many that the selection system was applicable to lodgepole, and, in fact, that the operations of an improvement thinning could be considered as an application of the pure selection system. This certainly is a wrong impression, since lodgepole is an intolerant tree which cannot reproduce in the amount of light which would be admitted by removing, let us say, one-seventh of the trees at every 20-year return. To make a heavier cutting than this would certainly be inadvisable, both on account of the windfall which would result and on account of the long period which would elapse before another cutting would be possible.

The Shelterwood System

The shelterwood system is just as far from being applicable to lodgepole pine as is the selection system. The application of the former requires that a light improvement thinning shall be made to strengthen the firmness of the trees, and that this shall be followed after a few years by a reproduction cutting, leaving an abundant supply of seed trees. The system cannot possibly be applied to lodgepole, because on account of the mixture of various sizes fully 30 per cent, by number, of the trees would be too small for the axe, even if reproduction had been established. More important than this, however, is the great age of lodgepole stands, together with the naturally small root system which probably cannot be strengthened by expansion when the tree reaches an age of 150 years or more. This means that the trees left for seeding purposes would all go down before their work had been accomplished, since undoubtedly a number of years would be required to put the seedbed in the proper condition for germination.

The Group System

The system of management which seems best applied to lodgepole pine is the group or group-selection system. It has been suggested on the basis of a 140-year rotation, with 20-year returns, that the groups to be cut should be about 60 feet in diameter, comprising about 1/15 acre, and that two groups per acre should be cut at each return. The advantages of this system and the applicability to lodgepole are shown herewith.

1. The location of groups could be made to conform to the location of the large and overmature trees, which occur in groups in almost every mature stand, and which will appear gradually in stands which are now of pole size.

2. The cutting at each return would comprise 2/7 of the volume of the stand, consisting mostly of the largest trees. Supposing a present, overstocked stand of 15,000 feet per acre, the cut would be at the outset 4,300 feet per acre, increased somewhat by the removal of individual large trees between the groups. This amount is sufficient for the present-day operator.

3. Openings 60 feet in diameter would admit sufficient light for the rapid decomposition of the humus, producing a favorable seed bed. Seed trees would be close at hand. The seedlings in each group would grow up practically under the conditions of an even-aged stand, though somewhat affected, of course, by the trees which surround the opening.

4. The desirable condition of clear cutting (necessary for reproduction) could be obtained without danger to the protective value of the forest. Even on steep slopes erosion would have no opportunity to gain headway.

5. Openings would not be of sufficient size to induce windfall. since the remaining stand would be largely intact. The groups of timber left for the last cutting would be those which were of the lowest age when the system was installed, and would have abundant opportunity to develop good root systems which would make them wind firm.

6. The matter of brush disposal would be simplified, since it would be possible to make in each opening one or two large piles, which could be burned without damage to the surrounding trees. The burning of the brush in these openings, together with the soil disturbances caused by logging, would produce ideal conditions for the starting of reproduction.

7. Reproduction starting in the openings would be free from damage at later cuttings, since, in every case, trees would be felled toward the

centers of the openings which were to be made. This is perhaps one of the most important items which a true selection system does not make provision for.

8. The bark damage to standing trees, which inevitably results in felling lodgepole, would be practically eliminated. This is of great importance, since lodgepole is a thin-barked tree.

It seems possible that this group system can be applied to any stand of lodgepole, with very slight modifications. Stands which contain a large number of small suppressed trees of great age, growing under large trees, would perhaps suffer some loss, but at best it cannot be expected that these suppressed trees will grow very well if freed from cover. Young pole stands would not be touched, except possibly for improvement. An improvement thinning would be made in these stands with the idea of developing groups of different ages or of distinct sizes. This might in some cases lead to the removal of a few dominant individuals which were in the minority, while in other cases it would mean the removal of suppressed individuals. In any stand of considerable area the needs of any operator for any kind of material could be satisfied, provided the forester always kept in view the desirable grouping of trees of the same age and the elimination from every group of those trees which are either older or younger than the major portion of the stand in that limited area.

SEED PRODUCTION AND HOW TO STUDY IT: DISCUSSION*

S. T. DANA, BRISTOW ADAMS, C. R. TILLOTSON, AND RAPHAEL ZON

S. T. DANA: The authors of the article entitled "Seed Production and How to Study It," in Vol. 6, No. 2, of the Proceedings of the Society of American Foresters, have done a valuable service in reviewing the attempts made by European foresters to solve the problem of seed production, and especially in suggesting a definite method of attacking the problem in this country. Although exhaustive investigations involving a tremendous amount of work have been carried on by such well-known foresters as Lauprecht, Schwappach, and Wimmenauer, results of real scientific or practical value have so far been very meager. A new method of investigation, which promises better results, has, however, recently been suggested by Russian foresters, notably Ogievsky and Sobolev,† and is therefore worthy of careful consideration.

Briefly this method proposes to determine the number of pounds of germinable seed produced per unit of area for a given forest type. This is accomplished by the study of sample areas so located as to be representative of the type. The total amount of seed produced on each area is found by means of sample trees, suitably proportioned among the various crown classes present. All of the cones on each sample tree are collected, and the seeds are then extracted, cleaned, weighed, and their fertility tested. The seed production of each tree is found by multiplying the number of pounds of clean seed obtained by its germination per cent. From these figures the seed production of the entire plot is readily found, and, finally, this is reduced to total seed production per unit area (per acre in this country).

With a sufficient number of plots and with observations covering a sufficient length of time, this method will theoretically give the seed production per unit area for a given type and for good and bad seed years. The practical application of such figures is obvious. For example, if the sample areas have shown that Douglas fir produces 500 pounds of seed per acre in a good seed year and 300 pounds per acre in a fair year, a National Forest containing 100,000 acres of Douglas fir type would

*The original paper, "Seed Production and How to Study It," by Raphael Zon and C. R. Tillotson, the discussion of which is printed in this issue of the Proceedings, appeared in Vol. VI, No. 2, of the Proceedings of the Society of American Foresters, October 15, 1911.

† The authors state that Sobichevsky's name was accidentally substituted for Sobolev's in the previous article.

produce in a good seed year 50,000,000 pounds of Douglas fir seed and in a fair year 30,000,000 pounds. Incidentally, the study would also yield much valuable information concerning periodicity of seed years and the external and internal factors influencing seed production.

Sobolev's method of investigation is an extremely interesting and suggestive one; whether it can be generally applied in actual seed collecting work in this country may, however, be open to some doubt.

Every one will probably agree that in a careful study of seed production the crop should actually be measured quantitatively, and not merely estimated ocularly. To describe the seed crop as poor, fair, or good, would be as inadequate and of as little value as to describe a stand of timber for which an accurate estimate in board feet was wanted as light, medium, or heavy. Furthermore, there can be no question but that the standard for measuring the seed crop should be the quantity of germinable seed produced, rather than merely the quantity of seed irrespective of its quality. This has been recognized in this country for some time, and germination tests are now made of practically all seed collected as a basis for determining the amount to sow in nurseries and in field operations. In the method suggested by Sobolev and elaborated by the authors the weight of the germinable seed is accepted as the standard. This is more satisfactory than the total number of germinable seeds if it is remembered that the number of seeds per pound varies widely not only for different species, but even for the same species in different parts of its range. For example, yellow pine seed from the Black Hills National Forest in South Dakota runs about 20,000 seeds to the pound, while from the San Isabel National Forest in Colorado it runs only about 10,000 seeds to the pound. There is every reason to believe that each seed of the Black Hills crop is as valuable as that of the San Isabel crop, in spite of its smaller size. Assuming that the two kinds of seed have the same germination per cent, a given number of pounds of yellow pine seed from the Black Hills is worth approximately twice as much as the same amount from the San Isabel Forest. This point must always be borne in mind in comparing the seed production of any species in different parts of its range.

The second essential feature of Sobolev's method is the determination of the seed production per unit of area by means of sample plots. On this point there may well be some difference of opinion. Whether the sample-plot method can be depended upon to give reliable results at a reasonable cost under all conditions appears questionable.

Measuring the seed production of a given stand is analogous to measuring its wood production. The latter can be done in either of two

ways: by the use of yield tables giving the contents of the stand per acre or by the use of volume tables giving the contents of individual trees in the stand. Yield tables are generally considered preferable whenever the forest is uniform enough to permit of their construction and ready application. For example, in even-aged, fully-stocked, pure stands, normal yield tables showing the contents of stands at different ages can readily be prepared from a sufficient number of judiciously located sample plots. Unfortunately the majority of the present stands in this country are not of this character. Most of them are irregular, either in age, density of stocking, or mixture of species, or often in all of these characteristics. While it is conceivable that empirical yield tables might be constructed which could be applied to such stands over more or less restricted regions, both their preparation and their application would be difficult. Consequently they have not been generally resorted to, and under such circumstances yield tables have been replaced in estimating by volume tables. These show for various species the contents of individual trees of different diameters and heights, or merchantable lengths. When properly prepared they can be used to determine the contents of any stand irrespective of its regularity, and thus have a wider field of usefulness than do yield tables.

The preparation of figures showing seed production per acre presents fully as many difficulties as the preparation of similar figures showing wood production, and such figures are, perhaps, even more difficult to apply than are yield tables. For fully-stocked, even-aged, practically pure stands it is entirely conceivable that a sufficient number of well-chosen sample areas would give results that could be generally applied to that type. In this country the method might be applicable, for example, in stands of second-growth white pine in New England, lodgepole pine in the Rocky Mountains, or Douglas fir in the Northwest. To obtain reliable figures, however, a large number of plots would have to be measured in order to cover variations due to differences in age, character of stand, and local conditions. The amount of work and the cost involved in such a study can be readily appreciated.

The great bulk of the forests in this country are mixed, uneven-aged, and irregularly stocked, and it is difficult to see how the sample area, or yield table, method of study can be applied to these. To select a reasonable number of plots which would give reliable figures of seed production per acre for mixed hardwood stands in the East, or for mixed yellow pine-sugar pine-incense cedar stands in California would be practically impossible. It is conceivable that if a sufficient number of plots were taken to cover all conditions the results could be generally used

over wide areas, but the cost of such work would be practically prohibitive. Sample plot work is both slow and expensive in studies of wood production; it is necessarily even more so in studies of seed production, which include the exacting task of collecting and counting the cones, extracting and cleaning the seed, and making germination tests of it.

Another weakness in the method of applying figures of seed production per acre to wide areas lies in the fact that seed production is an extremely local phenomenon. While with most species there is a general periodicity in seed years, it is nevertheless true that the seed crop, like fruit and agricultural crops, is affected by local conditions. In 1910, for example, there was a general deficiency of yellow pine seed throughout the West, yet in the southern part of the Black Hills and in places in Colorado there was an unusually good crop. In the same year Douglas fir seed was in general scarce, but in restricted localities in southern Montana the trees bore heavily. When the crop varies locally in this way, the application of an average figure to whole regions becomes extremely difficult. Seed production must ordinarily be studied locally and by individual areas.

If quantitative estimates of the seed crop are desired for practical use in seed collecting in certain localities, is the unit area method of estimating the most satisfactory? Cannot better results be obtained under present conditions by the use of tables showing the seed production of individual trees, in the same way that volume tables are used?

The article on seed production under discussion states that "the production of seed in forest trees is not a function of an individual tree, but is really the function of the whole stand, since the development and the life processes of each tree in the stand is determined by the density, composition, and age of the stand and by the position of the tree in the stand." This can be admitted without agreeing with the deduction that this makes it necessary to study the seed production of the stand by sample plots. Incidentally it might be pointed out that even in sample plots the individual tree is eventually used as a basis for finding the production of the entire plot. The wood production of a tree is just as much a function of the entire stand as is its seed production; but this does not destroy the value of individual tree studies as a basis for determining the wood production of the stand. It is universally recognized that volume tables prepared from a sufficient number of individual trees can be used to determine the volume of a given stand with as much accuracy as can yield tables. Why would it not be possible to prepare a similar table, called perhaps a "seed production table," which would give the same information for seed production that volume tables do for wood

production? Just what form such a seed production table should take could best be determined after the field data necessary for constructing it had been collected. Very likely it should be based on diameter and crown classes, rather than on diameter and height classes as in an ordinary volume table, since it is undoubtedly true that the crown development of a given tree largely governs its seed-producing capacity.

The data on which such a table should be based could be obtained by special studies, or in connection with the regular seed-collecting work. Each tree studied should be fully described as to its diameter, height, age class (exact age, if possible), crown class, and development, health and condition, and relation to the adjacent stand. A record should be made of the total number of cones and number of bushels of cones produced; of the total number of pounds of clean seed obtained, together with a description of the method of extracting and cleaning; and of the germination per cent of the seed. From these figures can readily be derived the total number of pounds of germinable seed produced by the tree, together with other data of value in the general study of seed production. The final work of constructing the table would be similar to that of constructing an ordinary volume table.

The application of such a table would, of course, be more difficult than the application of a volume table, owing to the fact that with most species good seed crops occur only periodically. One year, for instance, a given tree may produce a full crop of seed; the next few years little or none. This periodicity makes it necessary to prepare the seed production tables so as to show the average production of trees of different diameters and crown classes during good, medium, and poor seed years. This complicates the matter by making it necessary for the estimator to determine whether the particular tree under consideration is bearing a good, medium, or poor crop. There is no reason, however, why with a little practice this should not be entirely possible. Furthermore, this difficulty is not peculiar to this particular method of estimating, but is inherent in any method that might be used. It would be equally a drawback in applying figures showing seed production per acre. In either case the average seed production for a given number of years would mean practically nothing, since what is wanted for use in seed collecting is to know how much seed can be collected from a given area in a given year.

The study of the amount of seed production, either by the acre or by the individual tree, would naturally yield some interesting information as to the periodicity of seed production and as to the various external and internal factors affecting it. To solve completely the biological

problem of seed production, however, intensive work is necessary. This can best be carried on at regularly established experiment stations, where continuous observations can be made and elaborate research methods employed. Work of this character will be of the greatest scientific and perhaps practical value. It is not reasonable, however, to expect that a local study at an experiment station will give results which can be widely applied in estimating the amount of the seed crop at any given time, especially in stands of different character from those studied. Neither does it seem possible to join unreservedly in the authors' optimistic belief that "when the forester fully understands the laws of seed production he can control and stimulate it in accordance with his needs and be complete master of the situation."

Bristow Adams: While it is, of course, necessary that the greatest amount of scientific accuracy be brought to bear on all the problems that confront the Forest Service, it seems that there is not enough in the seed production problem conducted along lines that seek to influence external factors to justify the great amount of time, labor, and expense that are needed to secure results. It comes down to this in the last analysis: That trees or forests do have years of exceptional yields of seeds, but the periodicity of these years has not been determined or foretold. Even if it can be definitely determined that a tree bears a full crop every eight years, or the equivalent of a full crop in that time, what are the practical results of that knowledge? It will always be necessary to keep on hand an equipment sufficient to take care of a maximum fruitage, no matter when it shall occur.

Further, the authors of "Seed Production and How to Study it" say that "if the forester can control and stimulate it (seed production) in accordance with his needs, he will be complete master of the situation." There can be no question as to this. But suppose that it is determined exactly that precipitation or any other phenomenon of the seasons determines absolutely the production of seed! Does that carry the solution any further? Hardly; since it is not possible to affect these phenomena; we have not yet found out how to secure or to prevent an open winter or how to make certain a wet spring or a cool summer.

Moreover, seeds from one region are so readily transported to another that it can make but little difference about an abundant seed year in any given place, and the problem of artificial seeding is mainly one of storage An abundant seed year means many different things according to location, even with identical species. Longleaf pine in the Carolinas may have a maximum pine mast at a time when the Gulf Coast forests have

not any, and *vice versa*, yet the seed from either region is equally good for both, and the Gulf Coast seed will, in all likelihood, produce a tall, straight, Carolina-like tree in the Carolinas, just as the Carolina seeds will produce the shorter, smaller tree of the Gulf. Development depends mainly upon environment. Further, a maximum 100 per cent yield on the Florida National Forest is likely to be about the equivalent of a 25 per cent yield in the Carolinas, so that it might not pay to attempt to gather seed along the Gulf even in the best years, because it can be bought and brought in cheaper from another region.

On the whole, then, it seems that there are so many other problems that need to be worked out—problems of greater importance and with more immediately needed solutions—that the matter of seed production through an attempted control of the seasons can afford to wait, if not be actually left alone, and activities centered on studies of the tree itself, with a total disregard of any "determination of the various external factors which affect the amount and periodicity of seed production." Certainly, the investigations made so far have been purely empiric, and have yielded no results that can be utilized in practice; and they seem to hold no promise of any such results. An additional thought comes to mind: There ought to be sufficient preparedness for handling a seed crop, in the fact that in many forest trees two years are required to mature the seed, and ordinary observation can foretell a good seed year as long ahead as it need be foretold.

Mr. Dana and Mr. Zon each seem to have effectually proved the impracticability of the other's plan and the prohibitive expenditure of time and money that both schemes would involve.

As opposed to these, another simple and more promising line of investigation presents itself, dealing with individual trees alone, and depending not at all upon seasonal variation. An interesting vista of possibilities is opened up in the experiments that have been made along the lines of producing fruitage in barren trees. It is a well recognized fact among fruit growers that the partial girdling of an apple tree, or of a limb of that tree, produces many large, perfect fruits. This fact is so well recognized that pomological societies have legislated against it, and bar from competitions, for quantity or quality, fruits produced in this way. The same thing is shown in the old superstition that the driving of nails into a barren or comparatively barren tree will cause it to fruit. It is a fact that this treatment brings about the desired result, the superstition consisting in the notion that the iron rust from the nails secured the crop; yet the same thing can be got by boring holes in the tree, as demonstrated by Dr. Fernow on plum trees that had a superabundance

of moisture and soil fertility and had passed the age when they should have begun to bear fruit, without showing a sign of blossoming. After their partial girdling had been accomplished by having holes bored in them, they bore satisfactorily and continued to bear. Horticulturists and florists find that excess of plant food in the soil means vegetative growth and no flowers and fruits. Forcing for bloom depends somewhat on comparatively barren soil. The common nasturtium, in poor soil, but fertilized with liquid manure, will bloom only sparsely or not at all. Withhold the liquid manure, and it immediately responds with a wealth of flowers and seed pods.

This general principle, of which there are many manifestations, is said to be applicable even to the human race, according to some students of eugenics, who claim that poorly nourished peoples have marked fecundity—that the privation which follows warfare makes for more children—and that barrenness can be removed in individual instances by substituting conditions of comparative want for conditions of luxury. Professor Hadley says: "Statistics show that high comfort and low birth rate go hand in hand."

When we come to forests this principle, common to other life, ought to be applicable. In a study of Utah juniper, by Phillips and Mulford, it is stated unequivocally that specimens which have the hardest struggle in the most dry and barren situations bear by far the most seed. The same sort of thing is strikingly brought out in Professor Jepson's bulletin on tanbark oak, in which he says that the standing trees which have been peeled or "jayhawked," are girdled and four or eight feet of bark taken off usually before flowering time, and the growth of the tree is checked. "The second year the tree bears a full crop of acorns—often an excessively large crop." This phenomenon is so well recognized that the woodsmen have a specific name for it, and call it the "last kick" of the tree, since in the third year the tree is likely to die, though it may continue to live for a longer period—even 10 or 15 years. The apparent anomaly of the girdled tree continuing its life functions is explained by the fact that, in peeling, a thin portion of the inner bark and cambium layer adheres to the wood.

The application seems simple. Make experiments to see how much individual trees respond to a partial girdling in yield and fertility of seed. It would not take long to secure the results, and any question of periodicity need not enter in. Then, if it is found that the girdling does accomplish what is sought, it is easy to get a large crop, either for natural reproduction or for seed collection. If clean cutting is contemplated, for example, secure seed production beforehand. We have large timber

sales, covering several years. One or two years (according to the period for seed development) before the cutting begins on a given area, go in and mark the trees, and girdle them almost all the way around. Then get your abundant seed cheaply just before or after the trees are felled, according to the ripeness of the seed at the time of felling. You lose one or two annual rings, but their value would be infinitesimal as compared to the value of the seed and the assurance of its occurrence.

It is a natural law that the reproduction function is the chief end of an organism, and that provision is made to secure it in abundance when anything threatens the existence of the parent growth. Summing up: In experiments on seed production, it ought to be easier to control the tree than to control the elements; and a more rational set of results ought to be derived by subjecting various trees to various hardships to see how they will respond.

C. R. TILLOTSON and RAPHAEL ZON: Mr. Dana advocates the method of volume seed production tables which, in his opinion, is simpler and more direct than the method proposed by the authors of the original article. The method which he proposes is fully as open, if not more, to the same criticisms which he makes of the method described in our paper. At the same time, he admits himself that by his method he is not able to work out some of the most vital points in connection with a study of seed production which are worked out in the other method.

There are three important points about the method of studying seed production as presented by us, and these are: 1st, that the method has been applied not only in a fully-stocked, even-aged, practically pure stand of Norway spruce in Russia, but also in stands in that country in which several species occur in mixture, and it has been still further tried out in northwestern Idaho in a mixed forest of larch, western white pine, occasional Douglas fir, with an undergrowth of hemlock and white fir, with every indication of success, although the final figures have not yet been worked out; 2d, that by this method a law is established for determining the amount of the seed crop by other than a mere ocular estimate; and 3d, that by this method the periodicity of seed crops can be determined. The method proposed by Mr. Dana has not been successfully applied, and it is questionable whether it can be; it will not establish any law or criterion for determining the amount or character of the seed crop, and it will not enable the investigator to determine readily the periodicity of seed crops. The second point is the weak link in the method proposed by Mr. Dana, and it will lead to a number of difficulties.

The difficulty of preparation of seed yield tables in mixed stands is scarcely analogous to that encountered in preparing tables of yield of lumber, cubic contents, etc., of mixed, uneven-aged stands where the yield of all the species has to be taken into consideration. In the seed yield tables described, the investigator concerns himself with only one species, and that species is studied only in those types in which it forms an important part of the stand. In the seed production study, moreover, the ages of the trees under consideration are of little importance. If they belong to the same crown class—as, for instance, if they are dominant, codominant, intermediate, etc.—they will bear about the same amount of seed, irrespective of age. After a tree has reached maturity, say for conifers 60 years, its seed production will not vary considerably for the next 100 years, and therefore trees may vary widely in age; yet if they belong to the same crown class they will bear about the same amount of seed. When a stand becomes overmature, and begins to decline, its seed production also declines. Since a permanent forest type is determined by certain conditions of soil, moisture, temperature, and other external factors, it is of necessity more or less uniform in character, and while local conditions may exert some influence upon the seed crop in generally very unfavorable years, it is very questionable whether these local conditions do exert any appreciable influence in years generally favorable to seed production. Mr. Dana's statement, therefore, that in this method of seed production a large number of plots would have to be measured in order to cover variations due to differences in age, character of stand, and local conditions, cannot be accepted. By having only a few judiciously placed sample plots in each type, results could be obtained which would be applicable to the same type even over large areas where the same general conditions of soil, precipitation, and temperature prevail.

In the method defended by Mr. Dana it is necessary for the investigator to estimate whether the trees are bearing a good, medium, or poor crop, both in preparing his seed volume tables and in applying them. If the same investigator were to determine in successive years the seed crop, he might become expert enough to estimate to his own satisfaction whether the trees to which he wished to apply a volume table were bearing a poor, medium, or good seed crop. If one or more investigators had to carry on the work started by the first man, is it not very probable that their estimates of the crop would vary considerably from those of the first investigator? In other words, uncertain, variable personal equation would enter into the study, and there would be no definite way of making allowance for it. One man might, for instance, apply a medium-

seed-year seed volume table one year and another man a good-seed-year seed volume table in a very similar year. Because of this personal equation, also, what is to prevent two successive investigators from constructing seed volume tables, supposedly for two different kinds of seed years which, on comparison, prove to be similar enough to show that the two seed years were similar? Such a case, which is a very possible one, would involve the expenditure of a large amount of time and money in needless duplication of work.

In the sample area method, as proposed by the authors, it is conceded that it will be necessary to take sample plots in those types in which the species under consideration forms an important part. We maintain, however, that volume tables will have to be made for each of these same types. While general wood volume tables based on height and diameter may be and are applied to different types, it is generally conceded that they are not accurate. A seed volume table thus applied would be even much less accurate because the conditions which produce types may have a much greater influence upon seed production than they do upon form factors or volumes of trees of equal heights and diameters.

Mr. Dana has dwelt quite strongly upon the expense involved in studying seed production by our method. Where, because of an actual lack of funds, it is imperative to practice economy in some lines of work, the curtailing of expense in every possible way has some justification. In scientific research work, however, the expense should be the last consideration since the saving to be derived as the result of such studies will in the long run many times exceed the cost of the investigation. We do not consider this point relevant to either side of the controversy, but since it has been brought up, let us consider for a moment the manner and expense of preparing such volume tables, and also the method of applying them.

In order to construct a fairly good seed table for individual trees, it will be necessary to collect and measure the seed from at least 100 trees of each crown class. Estimating this amount of seed will not do. Now, how is this seed to be collected? Are the trees to be climbed and the seed cut or picked off each one, or are they to be felled and the seed thus collected? With some species, spruce in particular, where the cones are borne almost wholly at the very top, this method could probably be employed if steeple-jacks could be found who were willing to undertake the work; but imagine the collecting in this manner of the cones of Douglas fir, which are borne on all parts of the crown, or the collecting in hardwoods of the nuts of the beech or sugar maple, which occur in many thousands on single trees distributed throughout the crown. Such

a method is manifestly not to be considered as generally applicable to all species, and its expense would unquestionably be enormous with any species.

If, on the other hand, the trees are felled to determine their seed crop, and this is the only feasible method which can be applied to all species, think of the amount of work involved, and think further of what disposition could be made of the trees felled in preparing the table.

Another, and not the least expensive and time-consuming step in the preparation of such a seed table, would be in extracting, cleaning, and making the determinations of the number of seed per pound and germination tests of each lot of seed. This step in the preparation of such tables involves an enormous amount of work. Such seed volume tables must be prepared for different seed years: good, fair, poor, etc.

After the tables are prepared the investigator, when wishing to apply one of them, must guess which table to use: a good seed year table, a fair seed year table, etc; he must then lay off a sample area in each type, list the trees according to a complicated crown classification, a tedious and difficult operation, and then apply his volume table. This process has to be repeated not for one year nor for ten, but for every year that he wishes to estimate the seed crop.

It is perfectly obvious that the seed-volume-table method would prove to be much more expensive than the sample area method, and it would be much less practicable and subject to error because of the large amount of guess work and of the element of the personal equation which would enter into its application.

The two methods should be contrasted on one other very important point. Since the seed-volume method does not establish a definite criterion for determining the character of the seed year, it would not enable the investigator to determine the periodicity of seed years. It has already been stated that the sample area method does enable the investigator to determine this point. Where some form of natural regeneration is to be practiced in the management of forested areas, the determination of this periodicity is fully as, if not more, important than the amount of the seed crop. The time and the amount of the cut will be regulated and the success or failure of natural regeneration may be determined by the observance which the forester pays to this phenomenon.

Briefly, the following are the very vital points of difference between the two methods:

1. The sample plot method enables the establishment of a definite criterion for determining the character of the seed crop; the seed-volume-table method does not.

2. The sample plot method enables the investigator to determine the periodicity of seed crops; the seed-volume-table method does not.

3. The sample plot method is easier of application than the seed-volume-table method.

S. T. DANA: This discussion of seed production has touched upon so many phases of the problem that a few words, by way of summary and explanation of the method suggested in my paper, may not be out of place.

In the first place, it should be borne in mind that that method dealt only with the specific question of determining the amount of seed in a given locality available for seed collecting. The factors influencing seed production, including periodicity of seed years, would have to be studied in other more detailed investigations undertaken at experiment stations or elsewhere. In this connection it might be pointed out, in passing, that the method of study advocated by Mr. Zon and Mr. Tillotson, without modification will hardly succeed in establishing finally the laws governing the periodicity of seed years. To do this, the same trees or the same stand must be observed for a number of years under precisely the same conditions, while their method provides for cutting out certain of the trees and so altering the stand.

It is difficult to see wherein the sample area method provides a more definite criterion for determining the character of the seed crop than does the study of individual trees. In either case the estimator must determine whether the tree or the stand is bearing a good or a poor crop, and it is, if anything, easier to do this for the single tree than for the entire stand. The difficulties which Mr. Zon and Mr. Tillotson see in finding a standard by which to apply the "seed production table" are largely imaginary, and such as are not are equally true of both methods.

Their unqualified statement that the sample plot method is easier of application than the individual tree method hardly seems justified. The difficulties which they picture in collecting seed, while perhaps serious, are certainly not more so than in the sample area method; for in irregular stands the latter, to have sufficient basis to be at all accurate, would have to include so many sample plots that the total number of trees examined would probably be more than the number necessary to construct the seed production table. And after all this work, the applicability of the figures obtained to other stands differing in composition and density would be decidedly questionable. No doubt it has been found possible by means of sample plots located in a mixed forest of larch and western white pine, with occasional Douglas fir and an understory of hemlock

and white fir in northwestern Idaho, to find the seed production on those plots. Whether the figures obtained in this way will be applicable to other stands and in other years is, however, extremely doubtful.

As far as the question of germination tests is concerned, it will probably be found that tests will not be needed for all the trees included in the seed production table. The fertility of seed from trees in the same crown class does not vary greatly, and representative samples from the different classes will doubtless be found sufficient.

In actual seed collecting work, the collecting is done from trees bearing a good or at least a fair crop of seed. Consequently there is ordinarily no real need of including in the seed production table trees with only a poor crop. Possibly it would be sufficient for practical purposes to show only the average amount of seed produced by trees of different diameters and crown classes when bearing a good crop, since these are the trees from which the collecting will mainly be done. It can hardly be doubted that such a table would be easier of construction and application than a table based on sample areas.

In all of this discussion the relation of seed production to natural regeneration has been largely neglected. Mr. Adams, to be sure, dwelt upon the possibility of artificially increasing the seed crop of individual trees; and Mr. Zon and Mr. Tillotson mentioned the importance of periodicity of seed years in this connection. Even more important than these, however, is some definite knowledge as to the amount and character of seed produced by trees of different sizes, ages, crown classes, and degrees of health; and the effect upon their seed production of the opening up of the stand caused by lumbering. Such knowledge is essential in determining what trees should and should not be left as seed trees, and can, of course, be obtained only through a study of individual trees.

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FOREST RESOURCES AND PROBLEMS OF CANADA

BY B. E. FERNOW

(Delivered before the Society December 28, 1911)

Economic reforms, like social reforms, find their greatest obstacles in the conservatism, or, less euphoniously, in the inertia, which the daily usage, the routine, imparts. The difficulty of overcoming this inertia is the primary one in all reforms and among all peoples. Canadians are no exception. On the contrary, being largely of English stock, they are, like the Englishman, more conservative than their cousins in the States. Methods that have answered the needs of long ago satisfactorily are continued, although conditions have changed; the momentum of the traditional, the routine, carries their use beyond their time of adequateness.

Besides this conservative disposition and other frailties of human nature, the difficulties which surround the introduction of forestry methods in handling Canadian timberlands may, as in the United States, be classified in three classes, namely, natural, economic, and political. Natural and economic difficulties are in most cases working together.

The fact that the Canadian forests are largely of a mixed type, made up of species of unequal usevalue, some of which can be transported to market by natural waterways and others which cannot be so transported, makes it necessary to exploit and extract the one and leave the less desirable or useless—the tree weeds, relatively speaking—in possession of the ground. In other words, a deterioration in composition in consequence of logging, at least in the eastern forest, is almost unavoidable.

In the States, railroad development has proceeded at such a rate that the transportation problem and its influence on the manner of exploitation and its results has become less important than in Canada, where water transportation is still largely the only means of reaching a market. As near-by supplies are decreasing and the distance to market increasing, the cost of logging has indeed become so expensive in Canada that southern pine and cypress, not to speak of hardwood lumber, compete successfully in Canadian markets.

The market difficulty is increased by the distribution of population and of industrial development, which is also less satisfactory than in the States. This will readily appear from the statement that half the small population (say seven millions) of Canada is concentrated on the peninsula of Ontario and in the St. Lawrence Valley, and perhaps another third in the rapidly-filling prairie country; the woods country, which now still contains timber of marketable character, being far removed, hence close utilization is excluded. Moreover, the character of the woods country is not such as to invite much local industrial development, farm lands within it being very limited, and even timberlands of high value occurring more or less in pockets. Such contiguous timber areas of a valuable species like the pineries of the Southern States are unknown.

While these remarks refer mainly to the eastern provinces, conditions in the Rocky Mountain section and in British Columbia are not very different: the country is for the most part thinly populated and in the pioneering stage. Hence wasteful practices must prevail as long as private interests, pivoting around financial results, are left free to exploit the forest resource.

The thin population, the distance to market, besides the natural attitude of the pioneer, lead necessarily to wasteful practices, and make changes in methods of exploitation appear impracticable except in limited localities.

Even the fire problem is, on account of these conditions, more troublesome than in the States. Long stretches of country must be left to themselves on account of the absence of population and inaccessibility; undue expense of a protective service would be involved where so much valueless territory is interspersed among the valuable.

These unfavorable, natural, and economic conditions are unavoidable difficulties, but they are unnecessarily increased through the lack of knowledge on the part of the people of the actual conditions of their timber supplies and the need of more conservative use. Even now, persons in high and responsible positions prate of "inexhaustible timber resources"—a false patriotism apparently inciting them to boom the

country. The statement of the school geographies that Canada is a woodland country is being interpreted to mean a timber country. Even the statement that Canada is a woodland country needs modification, for at least one-third is treeless tundra, to which must be added the 200,000 square miles of forestless prairie and plains country, the extensive areas above timberline, and a large portion, perhaps 50 per cent, of the northern woodland country which is in swamps and muskegs or otherwise open, not to mention the unusually large areas of water surface represented in the innumerable lakes which stud the vast undulating interior plain.

A closer inspection of natural forest conditions of the Dominion reveals, first, that for her large size—with over 3.5 million square miles, larger than the United States—she is poorly timbered; secondly, that her valuable timber is unevenly distributed; thirdly, that the floral composition of her forest is extremely simple and of few species; further, that within the forest areas farmlands are scanty and mostly poor, and wastelands—rock barrens, bogs, swamps, and muskegs—plentiful. While there are endless woods, really good timber is limited.

Anything like statistical knowledge regarding Canadian forest areas is lacking, but by subdividing the country into types, measuring the areas occupied by such types, and estimating their probable production, the writer has come to the conclusion that as to area capable of producing commercial timber (not merely woodland) Canada may not claim much more than half that of the United States, say 250 million acres, and as to quantities of available saw timber, not more than one-quarter now still to be found in the States, say 600 billion feet B. M. of coniferous material.

Half of this timber may be accredited to the Pacific; the other half to the Atlantic side. In addition, a large amount in the aggregate of pulpwood and of inferior saw material, needful for local development, is found scattered through the middle portion.

While an enumeration of species occurring in Canada would develop the respectable number of 150, less than one-third are of commercial value, and, indeed, if frequency and quantity of occurrence are kept in mind as factors in determining economic importance, the number of important species will be found within 30, namely, 18 conifers and 12 broad-leaf species.

In order to understand the situation better, it is needful to subdivide the large country. By combining floral distribution with topographical, climatic, and geological features, the writer has divided the whole country into 12 types, which are located on the map, mainly by utilizing the

limits of the botanical distribution of commercial species based on notes furnished by the Canadian Geological Survey.

The Acadian type (I) is represented in the Maritime Provinces, together with the eastern townships of Quebec south of the St. Lawrence River. This is a continuation of the Appalachian range, occupied by the birch-maple-beech type with coniferous admixture, the same as the northern New England forest. The white and red pine having been largely removed, red spruce and hemlock are now the prominent lumber trees, with balsam fir a very frequent concomitant; black spruce and white cedar, in swamps; white spruce, rare in the forest, but prominent in reforesting pastures.

A closer survey of Nova Scotia (21,000 square miles) conducted by the writer gives some indication of conditions more or less typical of the whole section. Only about 20 per cent is in farms or fit for farming; another 28 per cent is natural or man-made barren, or recently burned (5.8 per cent); the 52.5 per cent of green forest is to the largest extent—nearly three-quarters—of mixed type, maple-birch-conifer, 20 per cent pure conifer, and the small balance hardwoods. Of virgin forest hardly 2 per cent is found on the mainland; a little over 22 per cent remains moderately culled; the balance severely culled and in second or young growth, less than 20 per cent of the latter. On the Cape Breton Island an interesting solid forest of balsam fir, with not over 15 per cent spruce and a small paper birch admixture, covers a plateau of 1,000 square miles in extent. An estimate of the coniferous saw timber remaining in Nova Scotia brings the total to less than 10 billion feet and the stand per acre to around 1,500 feet, besides two cords of pulpwood on the average.

The glacial deposits of the St. Lawrence Valley give rise to type II, a hardwood forest, in which perhaps elm and maple play the most prominent part, and conifers occur scattered or on sandy deposits in pure stands. Climatic differences permit a distinction into three subtypes. The southern (II*a*), occupying the Ontario peninsula, characterized by the mild climate due to the influence of the lakes and by fertile soil, supports a continuation of the luxuriant hardwood type of Indiana and Ohio, with tulip tree, walnut, hickory, oak, and chestnut, and such southern species as sycamore, coffee tree, honey locust, sassafras. Spruce and balsam are absent, and pine and hemlock occur only sparsely, but of fine development. These conifers, as well as the valuable hardwood timber, have mostly made way for farms, many of which lack even their wood-lots. Here is the garden spot of the Dominion, and here is found

the densest population. As a timber producer it is now almost negligible.

The middle St. Lawrence Valley (II*b*) along the shores of Lake Ontario, and following the river to within a short distance of Quebec, exhibits a more northern climate—wider ranges of temperature and lower humidity and rainfall—and also less fertile soil. Still, while, to be sure, the southern species found in the peninsula drop out, the type is similar to the foregoing. Most of this region, too, is under farm and the commercial timber cut.

A still further reduction in number of species characterizes the lower St. Lawrence Valley (II*c*) type, from Quebec north. The valley here is much narrower than the preceding and more rigorous in climate. It approaches the spruce type of the Acadian region on the southern, that of the northern forest on the northern side of the river.

Altogether very little merchantable material is left in this valley, which forms for the present the main agricultural lands in the eastern provinces. North of this region of drift soils extends the Laurentian plateau (III), a vast area of Archæan rock scoured by the ice, gradually sloping from the Height of Land southward and northward, topographically little diversified, the thin soil collected in pockets and only occasionally of sufficient depth and richness for farm use.

On the southern slope of this "Laurentian Shield" south of the Height of Land is located the true commercial forest area of eastern Canada, a country fit mainly for forest use. If we take the white pine as the most important timber, this area is still further confined in its eastern portion, for while in the western portion the northern limit of this pine very nearly coincides with the Height of Land, in the east the limit of its occurrence is climatically still further limited, and lies far south of the Height, namely, on a line from the headwaters of the Gatineau to Seven Islands, in the Gulf of St. Lawrence.

This is a country of lakes and swamps alternating with low hills and plateaus, most variably forested, although the flora is limited to few species. It would be difficult to pick the leading species in this territory of approximately 150,000 square miles extent. There is still a hardwood basis, in which maple, elm, basswood, and paper birch, with beech, red oak, yellow birch, ash, balm of gilead, besides the ever-present aspen on burnt areas, play a part. Of the conifers, balsam fir is probably numerically the most frequent, with white spruce a close second, and in the swamps the almost useless black spruce is prominent, with the more valuable white cedar and tamarac according to the character of the swamp. White pine and hemlock, the two most valuable species, and the red pine

occur much more localized, mainly along the waters and on the better drained sandy hills. A century of logging has removed the accessible pine very nearly, and while it is impossible to make even a guess of the amount still standing, the fact that hemlock is cut in ever-increasing amounts sheds light on the situation. The Ontario portion of this area has always been reputed to be better stocked with this class of timber than the Quebec portion. Yet the government officials, claiming on the unlicensed territory—which, by the way, in Ontario comprises still 140,000 square miles—10 to 12 billion feet of standing white pine (or one-third of the annual consumption of coniferous material in the United States), seem to think this a large amount.

Those who realize that the commercially available and accessible saw timber is near exhaustion point to the enormous amount of pulpwood material as the value for the future. There are undoubtedly large and for the present unmeasured amounts, but it should also be realized that a large portion of this, perhaps more than 50 per cent, is balsam fir, which, although according to the writer's contention superior to spruce for pulp, is not advantageously floated, and since the rivers are the only means for getting it out at present, and probably for a long time to come, it will remain unavailable until other values invite railroad development.

The cut-over lands are treated no better or worse than in the States. Fire sooner or later ravages them, and on the thin siliceous soil destroys not only the young growth, but the mould; the waters soon wash the soil, and the bare rock comes to view. Thousands of square miles have been and are being burned over repeatedly, and while the aspen and the banksian pine struggle to keep a forest cover, in many places the value is gone. The characteristic attitude of the authorities to this spoliation policy is exhibited in the declaration of a high official in charge of timberlands, that the extensive fires of the last season did not do much damage, since they occurred mostly on cut-over lands, *i. e.*, destroying only young growth.

Beyond the Height of Land, the Northern or Subarctic Forest (VIII-IX) begins. Although white and red pine are still found overlapping along the upper river courses, and although aspen, balsam poplar, and paper birch are frequent accompaniments, and sometimes sole occupants of the soil, the general type may be described as spruce forest, the white and black spruce being by far the predominant species. While the eastern portion of this region lies on the old granite rocks, its western extension lies on limestone formation. With a climate still more rigorous than in the last described region, and with still less topographical differentiation, it stands to reason that on this northern slope of the Lauren-

tian plateau, not only a reduction in the number of species to eight—besides those just mentioned only the banksian pine, balsam fir, and the tamarac take part in its composition—but reduction in development of individuals and of the whole forest is experienced.

This vast territory, comprising about 1.5 million square miles, has for the most part been only superficially explored, and the explorations have followed mostly the river courses.

At any rate, looking at the economic value of these northern woodlands, everybody must agree that their timber, although of inferior character, is of utmost value for home use by the prospective settler and miner, and of no commercial value to our eastern civilization, especially as the direction of down grades is away from markets. Nevertheless, that vast areas of these woodlands, probably 50 per cent, are destroyed by fire and are annually burned over must be considered an incalculable loss for the future.

If an attempt were made to further differentiate this northern forest, we might recognize a northern and southern section, the limit between the two being formed by the northern limit of the balsam fir, which coincides for most of its trend closely with the division line of the "Hudsonian" and "Canadian" life zone lately established by the U. S. Bureau of Biological Survey.* South of this line we may assume, and we know in part, that a better development of forest growth is found more frequently than in the northern section in which the balsam fir is absent and balsam poplar and banksian pine are rare.

As the foothills of the Rocky Mountains are reached by this northern forest beyond the 52d degree, it still continues northwestward into Alaska and to within a short distance of the Behring Sea and Arctic Ocean. There is, however, a change in the composition, two western species relieving two eastern. The balsam fir is supplanted by *Abies lasiocarpa* and the banksian pine by *Pinus contorta murrayana.* These latter two also mingle in a narrow, limited area southward, and the white spruce and american larch also invade the Rocky Mountain flora, while even the douglas fir from the west descends the eastern slopes for some 30 to 50 miles, joining the eastern flora.

The Pacific forest may regionally, and in part florally, be divided into four types, and in these, again, topographically, at least six subtypes can be differentiated, namely, the northern and southern Rocky Mountain type, the northern and southern coast type, and within each of these the wet and dry slopes and the alpine type.

* North American Fauna, No. 27. A biological investigation of the Athabasca-Mackenzie region.

Temperature conditions divide the British Columbia forest into the two northern and southern and the alpine types. Humidity is the determining factor for the dry and wet subtypes in each of these, and humidity, of course, is predicated by topography.

The topography here being extremely diversified, changes in composition and development are as diversified. West slopes and valleys opening to the west, under the influence of the winds from the Pacific Ocean are humid. East slopes and valleys withdrawn from the influence of these winds are dry to arid. An arid interior plateau similar to that east of the Sierras in the States divides the Rocky Mountains proper from the Coast ranges.

The southern Rocky Mountain type (VI) is an extension of the more southern flora, with the bull pine (*Pinus ponderosa*), the silver pine (*P. monticola*), engelmann spruce, and western larch as representative timber trees, with douglas fir, cedar, hemlock, and lodgepole pine in minor occurrence, to which the eastern white spruce may be added. This type, varying somewhat in composition and development, extends to nearly 53d degree latitude, then changes into a type of simpler composition in which the lodgepole pine plays a prominent part, covering the dry slopes and plateaus northward as far as they are wooded. *Larix lyallii, Pinus albicaulis,* and *Abies lasiocarpa* are the species of the alpine zone, above 4,000 to 5,000 feet up to timberline, which is found at 7,000 to 7,500 feet.

West of the Coast range, the celebrated Coast forest (IV), also an extension of a more southern flora, is found in a belt running for 200 miles north, and rarely broader than 50 miles at most from the shore, except at the southern boundary, where it reaches 150 miles inland, crossing the Canadian Pacific a few miles east of Yale. The large island of Vancouver is for the most part wooded in a similar manner. Here the douglas fir, in magnificent development, with the hemlock and giant cedar, are the main timber trees, *Abies grandis, Picea sitchensis,* and *Chamæcyparis nootkatensis* adding locally to the values. The fine timber, with diameters sometimes up to 12 feet and 300 feet in height, is, to be sure, not to be found in a continuous body, but according to topography varies with timber of poorer development. Generally speaking, the bottoms, benches and gentler slopes exhibit the heavy timber up to altitudes varying between 1,500 and 2,500 feet. Above this elevation there is found in some parts, for another 1,000 feet or so, another type still of commercial value, mainly of *Abies amabilis.* Above the 3,500-foot level only the scrubby or stunted growth of the Alpine type is found.

Along the coast and on the islands north to Portland Canal the northern Coast Forest (V) changes in composition to the simpler hemlock-spruce type, which continues all the way along the Alaskan shore to Cooks Inlet. It is mainly composed of western hemlock, sitka spruce, and yellow cedar, occasionally, where the soil depth is favorable, developing to good size, although mostly branchy and really much of it of inferior quality. The Coast range being a series of low, broken hills, rather than a continuous range, this type continues into the valleys of the rivers for a considerable distance from the coast.

The northern Rocky Mountain section is little known except that it is a dry section, the forest type (VII) corresponding to that condition—an open growth of lodgepole pine without commercial value.

A rough estimate of the acreage and stand of merchantable timber made by the writer a few years ago brings it to between 30 and 50 million acres [estimated as 15 million acres, besides the railway belt, by the B. C. Forest Commission based on present standards of merchantableness] and between 200 and 300 billion feet (192 billion feet and 40 to 50 billion feet in the railway belt, according to the Commission report). Of this, one-quarter may be assigned to the Rocky Mountain types, leaving the bulk to the magnificent southern coast types. It may be broadly stated that British Columbia now contains about half the merchantable timber of the Dominion.

There remain the three forestless types of country which comprise more than one-third the territory of the Dominion—the plains country, extending northward from the States (X); the prairie country (XI), surrounding the former to the north, with groves of paper birch and poplar, and the treeless tundra (XII), north of the northern forest.

It will have become clear from this differentiation that the commercial timber of Canada is limited and uneconomically distributed.

Turning now to the political difficulties, the ownership and methods of disposal of public timberlands need explanation. Ownership of timberlands, except in Nova Scotia, is still for the most part in the Crown. *i. e.,* they are State property, either under provincial or federal control, and hence, apparently, a rational forest management could be inaugurated at any time, if the owner so wished. Actually, however, this ownership is a snare and a delusion, at least for the largest part of the more valuable portions of this State property, for these portions are rented away for the cutting of timber under conditions which make the ownership of doubtful value.

The conditions vary somewhat from province to province, but are similar in principle; the timberlands are managed under a license system.

In New Brunswick, for instance, licenses or permits to cut the timber on certain tracts, called limits, are given for a series of years, renewable for 25 years. In Quebec and Ontario the license runs nominally for only one year, when it can be renewed, and is, in fact, regularly renewed as long as the licensee pays the ground rent—a certain sum annually per square mile—and the timber dues, a certain amount per M feet, etc., for all the wood actually cut. So far the license system seems unimpeachable: the government retains ownership, and leaves it to private enterprise to secure for it a revenue from its property. But there are three features added which vitiate the beauty of the plan.

It would, of course, be proper to prescribe certain regulations as to the manner of cutting the timber, with a view to preserving the productive value of the State's resource. It is, therefore, a commendable condition, practiced in Quebec, to restrict the cut to a diameter limit, differing for different species. But it must be considered an entirely immoral contract, when conditions are imposed which cannot possibly be carried out by any one who is not with certainty in continuous possession, as, for instance, the erection of mills of given size; and still more immoral, if the one contracting party, the government, reserves, as it does, the right at any time to change the conditions of the contract without timely warning. The lessee then is placing himself in the condition of being in the hands and good will of the lessor—a dangerous proceeding!

It is no argument against this charge of immorality that the government of Ontario, *e. g.*, has, as a rule, not taken advantage of its right, except to slightly increase ground rents and dues and to impose the duty of protecting the property against fire in a certain manner. Another not less immoral feature in the handling of the timber limits has been the practice of allowing pseudo-settlers to locate on portions of the limits, and thereby curtail the timber of the licensee. Even so, the license being only an annual one, there would appear little hardship in imposing these conditions; but there was introduced a worse feature, which practically forced the government to renew licenses as a matter of fairness, and thereby curtail morally its ownership rights. After 1867 the limits were placed on the market at auctions, and the so-called "bonus" paid by the highest bidder represented, as nearly as could be ascertained by cruising, the difference between timber dues and actual stumpage value, so that practically the owner of a one-year license to cut timber had paid full stumpage value for all the timber on the limit, which it would take years to remove, and thereby had a moral claim on the government to leave him undisturbed in possession, to renew his license, and also not to hamper him with new conditions.

This would still have been a condition with which the government could have dealt fairly, because the amount of the bonus paid was known, and could have been taken into consideration if any change of conditions had been contemplated. But the third and worst feature is still to be related. It became not only the practice to renew the annual license, but also to permit transfer of licenses to others. In this way timber limits became *quasi* private property and objects of speculation. Banks advanced money on the limits to the lease-holder for the bonus or otherwise, as if they were his property, and not the State's; and not *licenses*, but *limits*, were handled and changed hands in the market as if they were property, at prices paid by the last purchaser, which would fairly represent full stumpage value.

In this way the hands of the government were tied by the equity which the license holders and banks had acquired in its property. The licensees claim, so to speak, property rights in limits which actually they had acquired only a right to cut over for one year. It would take an unusually strong Minister of Crownlands who could recover in an equitable manner possession of the State's property with a view to introducing a conservative management.

These worst conditions refer to licenses issued in Ontario from 1867, when the bonus was introduced, to 1904. The licenses issued before that time, still held sometimes by original lessees, are at least minus the "wages of sin" represented in the bonus, and it should be easier to adjust them and remove the claimed ownership to the second and third growth. Since 1904 the bonus bid is made not as formerly in a lump sum, but by the *M* feet, in addition to the ordinary dues, the timber to be removed within a given time—not much of an improvement on older methods.

The government has lost its power to regulate the proper use of its property, except on the unlicensed lands and forest reservations. This condition of things, which refers more particularly to Ontario, is repeated in somewhat different detail in other provinces.

In British Columbia, where the limits have been handed over to speculators mostly without a bonus payment for 21-year licenses, lately the licenses have been made perpetual and the stumpage dues fixed at 50 cents, under the idea that owners will therein find an inducement for conservative use—a perfectly hopeless expectation and a perfectly unfair deal for the people. This year, however, a vigorous attempt has been made to organize a strong forestry department, which may be able to work out a scheme by which the damage may be undone.

The Crownlands of the Dominion, located in the new middle provinces and unorganized territories, itself are in a more hopeful condition as re-

gards the possibility of applying management, for they are mostly not yet under license and the Forestry Branch has really possession of them.

There is, however, a move on foot to hand over the public lands to the provinces in which they are situated. Indeed, within a few weeks it was decided to transfer the so-called railway belt to the province of British Columbia. The same reasons which are against handing the National Forests over to the States are valid against such transfer to the provinces. The federal government in both cases can better afford financially the difficult task of starting a forest management, while either States or Provinces would surely resort to the policy of exploitation.

There is still to be added to these inherited and natural ones the third difficulty, which hampers the speedier progress in forest reforms wherever they have been begun. It is the baneful influence of personal politics, the blight from which all public business suffers, wherever there is a lack of a standard for the appointment of civil servants.

The influence of the Civil Service Commission does not reach the so-called "outside service," the field force, which is appointed, as a rule, for political reasons, or is at least under political influence. The U. S. Forest Service has been lucky in having from the start been able to avoid this influence, and to divorce appointments, at least to a large extent, from political considerations. The Forestry Branch of the Dominion has had to steer through political waters, and while it has been allowed to employ technical men without reference to their politics, the politics of other appointees rather than their fitness had to be considered, with the inevitable result of leading to inefficiency rather than to efficiency. Certainly, the splendid spirit of the U. S. Service could hardly be secured with such uncertain tenure.

So far, technically educated Canadian foresters have been few, and, with the sudden development of the British Columbia Forestry Branch, the market is indeed for the time undersupplied. With the increase in the number of professional foresters, however, it is to be anticipated that reform in organizing the forest service will grow apace, and that Ministers of Crownlands will be forced by public opinion to divorce technical administration from political influence.

Only a radical change in attitude, a realization that forest conservation is a present necessity, and that existing methods are destructive of the future, will bring forward the needed reform.

BORDER CUTTINGS—A SUGGESTED DEPARTURE IN AMERICAN SILVICULTURE

BY A. B. RECKNAGEL

(Contributed)

American forestry is frankly dependent on natural regeneration except in emergencies. To secure this we have, almost universally, adopted a selection system of cutting, which, starting with a crude diameter limit method, has evolved into a shelterwood selection method, somewhat along the lines of Gayer's "Femelschlagform." This method aims, briefly, to cut over an area now, leaving about one-third of the merchantable stand for purposes of regenerating the area naturally and to form the basis of a second cut in about 30 to 50 years. It is nearly five years since this method was inaugurated in the National Forests, and as yet the results have not been reassuring. Of course, no method of natural regeneration expects to secure a complete restocking of the area; there are always some fail places which must be restocked artificially.

But admitting that a satisfactory regeneration is secured in the 30 to 50 years following the cutting, what happens in the meanwhile? The area, with about one-third of the merchantable stand still on it, is subjected to all the injurious effects of drouth, insolation, and storm, as well as of snow, frost, fire, fungi, weeds, and insects. The larger the cutting area the more these will make themselves felt. The one-third of the stand left is not sufficient to prevent a strong drying-out of the soil by sun and wind; much of the precipitation is caught by the trees left standing, and thus does not reach the ground, while in times of drouth the larger trees rob the reproduction (seedlings) of much of the ground moisture which is the latter's due.* Similarly, windfall is increased, and the growth of weeds and sod fostered to the detriment of any tree seed which may try to germinate thereon. Snow break and frost damage is accentuated, as is also the danger of insect and fungus attacks. Finally, the danger of disastrous fires is multiplied, not only because of the unavoidable debris left after logging, but because of the large con-

* An excellent instance of this is found near Eberswalde, Germany, where three and four year old plantations under shelter of mature trees suffered more from the great drouth of 1911 than did similar plantations standing in the open.

tinuous areas of highly inflammable seedlings. It is probably true, also, that lightning damage, with its attendant fire menace, is increased.

In Europe the history of forest management has gone through the stages of extensive selection cutting, leading to systematized shelterwood or selection methods (Schirmschlagform, Femelschlagform, Plenterschlagform), with many variations. It is highly significant that in Germany these methods, practised as they were on large areas (Grossschlagwirtschaft), proved so uniformly unsatisfactory that they were abandoned in favor of clear cutting and artificial regeneration (Kahlschlagbetrieb), which characterized German forestry in the nineteenth century. The tremendous expense and manifest drawbacks to this method (deteriorating soil and yield, insect and fungus ravages, etc.) have led the foremost German foresters back to a systematized selection system—but one based on small areas (Wirtschaft der kleinsten Fläche) in contrast to the large area management of former times—with natural regeneration and well-distributed age classes, but with stands approximately even aged.

This last requirement is the result of dearly bought experience in the old shelterwood and selection cuttings, where much of the laboriously achieved reproduction was destroyed in removing the larger trees which had been left. Can we expect better results when the time comes for a "second cutting" 30 or 50 years after the first?

In his "Grundlagen der Räumlichen Ordnung im Walde,"* Professor Wagner, of Tübingen, describes a method of selection border cuttings (Blendersaumschlag) which offers a way to avoid these strong disadvantages of a "straight" selection or shelterwood cutting. In its essentials this method is a progressive selection-strip cutting from north to south, which utilizes the mature products in selection cuttings, at the same time securing natural regeneration of the forest. The strips or "borders" run east and west; they are narrow, since this is the most favorable to natural regeneration; they progress from north to south, since the closed, mature stand on the south side affords the maximum protection from drouth, wind, frost, snow, and the like without preventing the free access of precipitation to the regenerated area. The progress of the cutting and of the regeneration depends primarily on the degree to which reproduction has been secured and the needs of that reproduction. This progress of regeneration over the cutting area can be likened to the reading of a printed page, where the eye sweeps from the top to the bottom, line for line, steadily withal, yet halting occasionally until some difficult passage has been mastered.

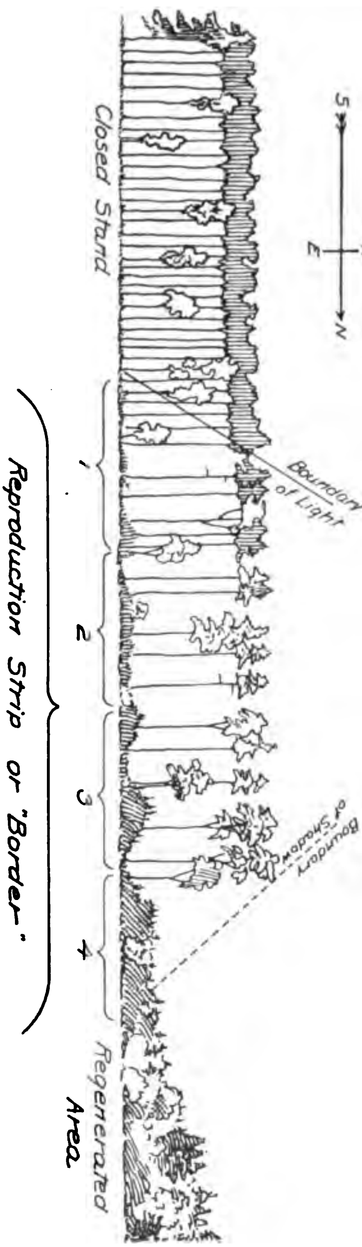
* Second edition, 1911, H. Laupp, publisher, Tübingen, Württemberg, Germany.

Is this method applicable to our conditions?

In the first place it is not chimerical as it might appear, but is based on 15 years of practical experience in Württemberg. The same basic principles hold good in America; but the method must be modified to meet our more extensive conditions. We cannot market where and what we will, but only "where" the proposition can be made attractive to some lumberman and "what" is merchantable. The purchasers of stumpage would likely object to a method of successive strips, but their objections would be tempered by the fact that they get all the merchantable material on the area instead of only two-thirds as formerly. This, of course, is also of substantial advantage to the forest owner, offsetting the expense of more rigid fire protection on an area without seed trees.

The total width of each strip should usually not exceed four mature tree heights, or about five chains (330 feet), and represents all gradations from clear cutting at the outer edge to the closed stand at the inner edge. The strips are not cut clear at first (except the initial border, which allows access of light to the area to be regenerated), but are cut according to the selection system. The entire strip is composed of four parts, from the inside outward (see accompanying sketch). These are:

1. Bordering on the closed stand: cut lightly, with a view to encouraging germ-



Profile of a Cutting Series in Selection Border Cuttings

Adapted from page 154, 2d edit., Wagner's "Die Grundlagen der Räumlichen Ordnung im Walde"

ination of the seed. (This would usually remove one-third of the merchantable stand.)

2. Cut moderately, so that seedlings may develop. (This would usually remove two-thirds of the original merchantable stand.)
3. Cut all but a few "protectors," so that seedlings may be prepared for standing without an overhead shelter.
4. Clear cut; no overhead shelter, but protection from mature trees on strips 3, 2, 1, and the main stand adjoining these. (This would usually remove everything merchantable—*i. e.,* generally all over 6 to 12 inches D. B. H.)

Thus the cutting advances gradually into the closed stand. This progress is usually about two chains per annum, but should be varied to meet the specific conditions. The method aims to utilize the seed which is produced each year, and thus in years when little or no seed is produced the selection cuttings are not pushed on into the closed stand, but attention is centered on the seedlings already secured. At the prospect of an ample seed year the selection cuttings are pushed farther than usual into the closed stand in order to utilize the larger production of seed. In this manner the effects of a bountiful seed crop can be extended over several years. The method is essentially flexible in its adaptability to the needs of various species and sites, though it is primarily suited to coniferous forests. Thus in regenerating light demanding species the clean-cut strip can be wider; in tolerant species not so wide. Again, on steep slopes or easily eroded soils the clean-cut strip can be kept narrow.

The method admits of modification very easily and brings into play the keenest judgment of the trained forester. For example, it allows the very desirable natural creation of mixed stands, through the variety of shade and shelter which it offers. This can be encouraged by removing large, heavy-crowned tolerant species first, then those of medium tolerance, leaving the intolerant species (provided they be wind-firm) to the last to scatter seed and to furnish protection to the seedlings (mostly of tolerant species) below and around them.

The brush disposal is identical with that now in vogue; the decay of the debris is, of course, accelerated because of complete exposure to the elements. In general, brush scattering is recommended where the fire menace does not necessitate partial or complete burning.

The absolute north to south progress of cutting is, of course, only possible on comparatively level ground (slopes of 5 degrees equal 9 per cent or less). In mountainous country the direction of the cuttings must be such that the material is always removed down hill. Therefore, the normal north to south direction need not be changed on slopes facing

the east, southeast, south, southwest, or west, but on the northwest, north, and northeast slopes the borders should run up and down the slope, progressing in a southwest, west, and southeast direction respectively. This change from the customary north to south direction will have no ill effect silviculturally, since northwest, north, and northeast slopes are *ipso facto* protected from undue sun, and therefore are usually moist enough to encourage seedling growth.

Logging is made easy in this method if, as far as possible, the main skidding trails or skid roads are laid out running north and south between the cutting series. These will also serve as boundaries between the areas, and on occasion may be kept as permanent roads or as fire lines. In logging all material is moved away from the regenerated parts; hence the method minimizes injury to young growth during removal of the mature crop; the mature trees left as "protectors" are removed while the reproduction is still in the seedling stage, when damage is negligible, whereas in a later stage it is often exceedingly damaging to the laboriously achieved regeneration and may destroy it entirely.

Any fail places which persist after ample opportunity has been given for natural regeneration must be seeded or planted. This measure is inevitable in any method of natural regeneration; it is minimized in the "border" method, because of the favorable position in which the stand is placed for natural reproduction, and the prevention of injury to the established young growth in the "second cut."

The final remaining strip should be regenerated by a groupwise selection cutting unless, of course, it joins on to a closed stand of seed-bearing age.

As for the distance between the cutting series or points of attack, this depends on the time within which the entire area must be regenerated and the size of the area. The quicker an area must be cut over and the smaller it is, the closer together must the cutting series be. Conversely, the slower the area can be cut over and the larger it is, the farther apart can the cutting series be; but in order to secure the manifest advantages of a relatively even-aged stand—*i. e.*, ordinarily one with no greater divergence than 30 years in the age of its component members—the cutting series should seldom be more than 60 chains (three-quarters of a mile) apart. This is based on an annual progression of two chains, a factor which must be varied as local experience dictates.

Assuming a unit area and different periods in which it is to be cut over—*i. e.*, regenerated—we get the following table of factors. (Areas to be regenerated in a single cutting extending over less than four or five years, of course, do not come under this method:)

Period of cutting—years.	Distance between each cutting series—chains.	Average amount per cent total stand to be cut each year.
4	8	25
5	10	20
6	12	$16\frac{2}{3}$
8	16	$12\frac{1}{2}$
10	20	10
20	40	5
30	60	$3\frac{1}{3}$
40	80	$2\frac{1}{2}$

This may be shown diagrammatically as follows: Assuming as unit of area a square section (640 acres), with an average stand of 5,000 feet, board measure, per acre, a total of 3,200,000 feet for the whole section.

In its application this method presupposes a careful division of the cutting area into types and the notation of the areas of burns, blanks, previous cuttings, young growth, and the like. The average stand per acre must also be determined for each type. All these data and more are already required in the timber estimate and forest description of the Forest Service and in the reconnaissance estimates, maps, and descriptions as well.

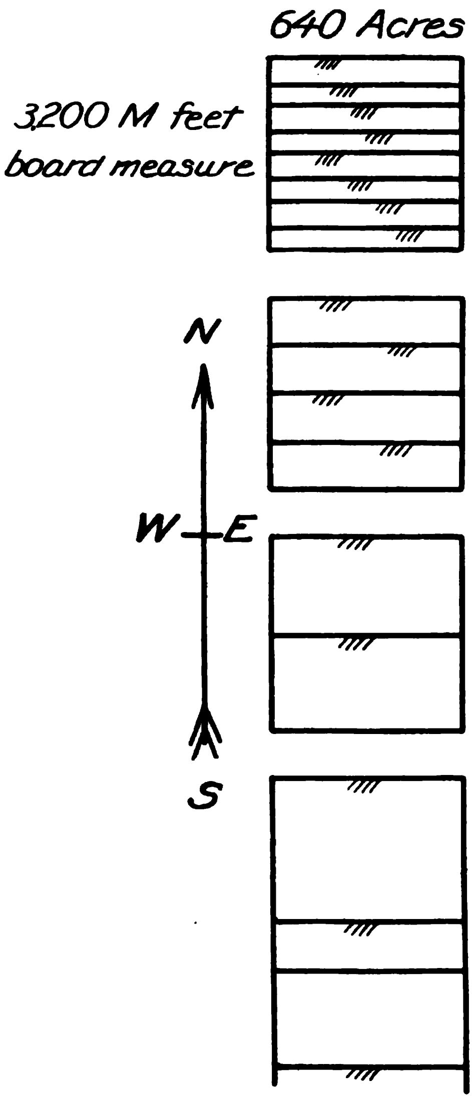
In this method area and volume check each other—*e. g.*, knowing the volume to be cut each year the requisite area can be worked over, and conversely. The method facilitates and systematizes supervision and administration. The marking of the trees in the selection cutting, the supervision of the logging, and the inspection of the resultant regeneration are made simple in so definitely bounded an area.

The final result will be a segregation of the age classes, each in their proportional area, with even-aged stands instead of the all-aged, or at best several-storied forest, which results from the usual shelterwood and selection cuttings. Thus the method leads over to a regulation of yield by area according to age classes, which has come to be considered the "ultima ratio" of systematic forest management.

As to the increased menace—*i. e.*, that fire may destroy the entire reproduction without leaving any seed trees present to restock the area—it may be repeated that the increased yield will allow of more extensive methods of fire protection, and that in general the practice of forestry presupposes efficient fire protection, especially of young growth.

The practical application of this method in America depends on the accessibility of all parts of the tract to be logged, which means a well-developed system of roads or other method of transportation. It will meet with the best success on good fresh soil and with coniferous species. In regenerating hardwoods such elaborate protection from storm and drought is seldom necessary.

Since it is not intended for use in regenerating areas that are to be cut over in less than four or five years, it, unfortunately, is not applicable to the majority of Forest Service timber sales, unless there be assurance that a given area of timber will afford a continuous cut for a



Five-year cutting period.
Eight cutting series.
Each one-eighth mile apart.
Each cut per year, 80 M.
Total per year, 640 M = 20 %.

Ten-year cutting period.
Four cutting series.
Each one-quarter mile apart.
Each cut per year, 80 M.
Total per year, 320 M = 10 %.

Twenty-year cutting period.
Two cutting series.
Each half mile apart.
Each cut per year, 80 M.
Total per year, 160 M = 5 %.

Thirty-year cutting period.
One and one-third cutting series.
Each three-quarters mile apart.
Each cut per year, 80 M.
Total (per 640 acres) per year, 106 M = $3\frac{1}{3}$ %.

longer period than that, and that the mills to which the logs go constitute a steady, reliable demand for all the timber cut in the period of regeneration.

Unfortunately, this combination of conditions is still rare in America. Occasional opportunities, however, are already at hand—for example, in some of the spruce forests of the north woods. These opportunities will continue to multiply, and the forester should therefore bear in mind a method which offers:

1. Natural regeneration with a minimum of loss.
2. Utilization of all the merchantable timber instead of leaving a large percentage as seed trees.
3. Easy logging and brush disposal.
4. Simplified administration; easier regulation of the yield through the systematic development of age classes.

Black Forest, Germany.

GRAZING IN THE NATIONAL FORESTS

BY L. F. KNEIPP

(Delivered before the Society February 29, 1912)

We have in the National Forests of the United States 159 enormously productive sources of wealth, and it is the function of the Forest Service to so administer these resources of the people as to meet best and most fully the economic needs of the whole nation. Even if timber were the sole product of the land, the performance of this function would be attended with many almost insurmountable difficulties; but there are, in addition, the forage products and the mineral products, utilized under differing and often conflicting conditions, which render the problem a most complex one. The mineral products, being imperishable pending utilization, may be dropped from consideration; but there still remains the question of whether a given area of land in Government ownership will best subserve the interests of the people by producing timber or forage.

Under present conditions the forage crops produced by many of the National Forests rank in value and importance with the forest crops, and often are paramount. In many parts of the West live stock is still the principal export product—the one commodity which draws foreign capital into local circulation. The benefits of the industry are far-reaching: they influence the welfare of the farmer, the merchant, the banker, and the professional man; they are the balance between the profitable and permanent settlement of many parts of the West and failure and abandonment. The conditions which render this true are, of course, transitory. As more diversified and intensive methods of farming are introduced; as means of transportation to market centers multiply and improve; as new industries develop and afford new outlets for raw products and surplus labor, the dependence upon the range will diminish and cease to be a factor demanding first attention. Then, too, as the practice of forestry progresses there will be a more accurate determination of land values; non-forest lands will be devoted to other uses; the forest cover will be extended over all of the potential forest lands and the by-product of forage will be negligible.

This, however, is looking into the future, and it is not probable that the changes occurring during the next decade or two will materially alter

the existing conditions. We will still have a natural resource of great economic value which should be converted to a beneficial use; we will have many communities whose very existence will be dependent upon the utilization of that resource; we will have a fire risk which can be appreciably moderated by properly regulated grazing; we will have a steadily increasing demand for meat products. The Western stock-grower makes two not wholly extravagant claims for his industry: 1, that it was the most potent of all influences in promoting the settlement of the Great American Desert; 2, that it made meat a common article of diet upon the table of the poor man, where before it had been a week-end luxury. One-seventh of the great Trans-Missouri region has been reserved for National Forests, and while the continuance of this land in Government ownership will promote rather than retard the intensive development of the West, the manner in which it is administered will have a well-marked and definite effect upon the volume, and therefore the price, of meat products. No system of forest management can be successful which does not take account of these conditions, and in some small degree subordinate its requirements to the needs peculiar to a given region.

What is the real importance of that part of the live-stock industry which is dependent upon the National Forests? The approximate annual product of the sheep is 7 pounds of wool per head, and a natural increase equal to 70 per cent of the stock covered by permit; the annual product of the cattle and horses is equal in numbers to 20 per cent of the permitted stock. During the year 1911 permits were issued for 7,449,415 head of sheep and goats and 1,443,438 head of cattle and horses, while in addition about 50,000 cattle and horses were grazed free. The estimated annual product of this stock was, therefore, 52,000,000 pounds of wool, worth about $7,800,000; 4,470,000 lambs or sheep, worth about $11,000,000, and 298,700 head of cattle and horses, worth about $6,000,000, or a grand total of about $25,000,000. Excluding Texas and Oklahoma, we find that about 27 per cent of all sheep in Western States are provided with range within the National Forests. Dropping from consideration the States of Texas, Oklahoma, Kansas, Nebraska, and North and South Dakota, where the number of cattle and horses under permit is negligible when contrasted with the State totals, it develops that the cattle and horses grazed upon National Forest lands constitute 15.6 per cent of all cattle and 3.6 per cent of all horses within the Western States. The relatively low percentage of cattle and horses is due largely to the fact that the State totals include dairy cattle and work horses, classes of stock which are necessarily confined to farms.

These percentages cannot be accepted as wholly accurate indications of the degree to which the various communities are dependent upon the National Forest ranges; some communities are only slightly dependent, while others are entirely so. At the same time these percentages give one some idea of the relation between the stock-grower and the Government forester.

Why does the welfare of many Western communities depend upon a use of National Forest ranges? First, because the agricultural products of that part of the West adjacent to the National Forests are largely forage or grain crops of large bulk and comparatively low values, which cannot profitably be hauled the distances that separate ranch and markets. The most economical and often the only means of utilization is to convert them into meat products by feeding them to live stock, which can be marketed with greater ease and less expense. Second, because stock must be removed from the fields and meadows during the period of plant development, in order that a maximum crop yield may be obtained. Third, because the uncultivated lands outside of the National Forests are inadequate to provide pasturage for the numbers of stock required to convert the surplus farm and forage products into merchantable commodities, partly because they are insufficient in area, but largely because low elevation and scanty precipitation tend to render them barren of forage during the period when it is most urgently needed. Fourth, because the favorable conditions of succulent feed, abundant and pure water, low temperature, and freedom from insect annoyances, so essential to secure perfect finish in flesh and form, are largely to be found within the National Forests. The Forest Service, in point of fact, has almost a monopoly of the choice summer ranges of the Western States—ranges which are as essential to the stock-growers as their home ranches and their haystacks. If these ranges were withdrawn from use, the resultant shrinkage in the volume of products and receipts would be enormous.

None of our domestic animals have any inherent qualities which should render them obnoxious to the forester. If allowed to follow their natural inclinations the damage which would mark their use of forest lands would be almost negligible and more than offset by the benefits. The fact that under present conditions the pasturage of forest lands is an antagonistic use is attributable, first, to the greedy indifference to future benefits which prompts the individual to overstock and destroy to realize a slight temporary profit; second, to the methods man has devised to maintain control over the animals. While the production and utilization of the forest crop has become an exact science based on well-established natural principles, the production of the range forage crop has until recently

been left to Providence, its utilization governed largely by the laws of chance.

The forage growing upon the unreserved and unappropriated lands of the United States has always been the free spoil of any person who possessed the means to convert it to his own use and benefit. The result has been the wastage and abuse of one of the great natural heritages of the nation. The era which is just coming to a close bred peculiar types of men and equally peculiar methods of range management. The man needed and developed the wit to outgeneral his competitors, the courage to conquer the wilderness and overcome the difficulties which beset him. He grew impatient of restraint, and exalted his empirical standards and principles above all others. He adapted his flocks and herds to their new environment; developed new methods of range management destructive, but successful; shaped his operations so as to best meet the new conditions and survive the fierce competition between individuals and classes. Often he deplored the need which drove him, but it existed, and he was compelled to meet it. The price he had to pay for his range was the exercise of strategy, often of force, and this involved enormous wastage.

The National Forests represent 190,000,000 acres of the public domain suddenly reserved and placed under governmental control. The range problems occurring within them were common with those of the uncontrolled lands. The methods governing their use were as destructive, and they were subject to the same misuse and abuse. The men who used them were of the common type. In their minds the principles of conservation and forest protection were idle and theoretical; improved methods of use impracticable. Where the introduction of advanced methods of forest management conflicted with the requirements of their industry they opposed such methods. To the trained forester, the only hope for the forests seemed to lay in the more or less complete exclusion of live stock.

For reasons given, exclusion, or even very material reductions in numbers, was impracticable if not impossible. The alternative was to regulate grazing—to devise means of prevention or cure. Gradually a system of constructive range management was built up, a system unique in the history of the country, and at present the most advanced of its kind in the United States. By the division of the range; by the determination of proper periods and methods of use; by the enforcement of well-grounded protective regulations, and by the creation of improved facilities for handling stock, the damage to the forest was lessened, the benefits multiplied. This system has been effective for seven years.

To what extent has grazing under this system of regulation conflicted with the progressive development of the forest resources? The answer to this question depends largely upon the factors of forest type, forage, soil, moisture, character of use, and temperament of investigator. We have on the one hand many instances where the forest cover has encroached steadily upon the grazing lands to the exclusion of the stock; on the other, many instances where grazing has unquestionably retarded the natural reproduction of the forest. Within the majority of the National Forests the net result is debatable; benefit and injury must be analyzed and rated before conclusions can be reached. Generally, recognition of the needs of the stock industry has entailed some sacrifice of silvicultural development. As more refined and intensive plans of forest management are adopted and applied this sacrifice will become greater, unless there is a corresponding advancement in methods of range management.

Damage to the forest arises from two general causes: First, the actual consumption of tree seedlings. This occurs only when there is shortage of proper plant food or an absence from that food of certain acid or alkaline requirements essential to the well being of the animals which are partially supplied by the seedlings. In other words, damage of this character is due either to overstocking of ranges or neglect, and except in some small degree it is remediable. The second cause is the destruction of the seedlings, directly by trampling animals or indirectly by destruction of ground cover, compacting of soil, with consequent loss of moisture, or by erosion and exposure of root systems. The benefits are: first, a diminution of fire risk by the removal of enormous quantities of vegetation, which, if allowed to accumulate and dry out, would greatly increase the difficulties of effective fire protection; second, the creation of soil conditions favorable to natural reproduction by the removal of a competing ground cover and the exposure of the type of soil essential to the successful germination and growth of tree seeds.

It will be observed that the evils of grazing may be remedied by the prevention of overstocking, by the requirement of proper care of the animals, and by certain changes in the present methods of handling the stock, whereby the grazing of large numbers of animals in compact bodies, or the constant assemblage of large numbers of animals at central points, or the use of forage at times when it is not suited to the stock may be obviated. This change in plans of operation, which is almost revolutionary, must be accomplished without serious disturbance of the live-stock industry, and to make it fully effective it must be made attractive to the stock-grower by its practicability and its offer of greater

financial returns. The first step must, therefore, be to provide more feed, more and better distributed sources of water supply, more facilities for handling the stock, better means for reducing annual natural losses and for lowering costs of operation. The range reconnaissance work which has been initiated by the Forest Service has these objects in view; it is the first step in a comprehensive plan of improvement and development designed primarily for the betterment of forest conditions, because forest management must at present proceed along the lines of least resistance, and for a time must be coördinated with range management rather than opposed to it.

What may one logically deduce from these facts? First, that the economic requirements of the Western States demand a complete utilization of the forage products of the National Forests pending the time when such products give way to forest products; that while pasturage might be provided elsewhere for much of the stock now dependent upon the National Forests, exclusion of stock during the transition period would inevitably mean an annual loss of many millions of dollars, which, because of its influence upon the prosperity of the communities or commonwealths concerned, might be considered indefensible. Second, that a grazing use, when properly regulated, is not inconsistent with a forest use, but, to the contrary, may be made to contribute materially to forest development. Third, that the Forest Service is obligated to exhaust every means within its power to devise methods and measures whereby the complete use of the forage may be secured with a minimum of injury to tree growth, so that a sacrifice of a great industry to a national need will not be necessary until it becomes unavoidable through changed economic conditions common to the entire country.

As the administration of the National Forests continues and as the investigation of range conditions progresses it becomes more and more apparent that the grazing of stock under fence means not only a largely increased monetary return from the forage crop, but a large reduction in the volume of damage done by stock. Fences, however, are regarded as semi-permanent investments, and if allowed would unavoidably be considered as liens upon the lands enclosed at least during a period sufficient to insure a return upon the capital invested. They would therefore localize what is at present only a general interference with the practice of intensive forest management, and might therefore delay the application to the National Forests of advanced principles of administration.

One important factor in the future administration of the National Forests will be the inevitable adoption of a system of range control upon

the unappropriated public lands. Obviously the system of range allotment must be coördinated, the methods of range control standardized and made uniform. All legislation hitherto urged for enactment has contemplated both a per capita permit and a leasing system, and undoubtedly the legislation which will finally be enacted will so provide. In such event it will be necessary to make some radical changes in National Forest rules and regulations and for a time these changes may have a disorganizing and detrimental effect, but the final result will be beneficial.

The future relation of the National Forests to the live-stock industry is difficult to forecast. So long as they produce stores of valuable forage there will be a strong demand for its utilization. Eventually the cattle baron and the sheep king will pass out of existence, the large herds and flocks of the present widely distributed, but the small farmer in the valley and the rugged mountaineer occupying the fertile glades and benches of the mountains will strenuously oppose the exclusion of their stock from the forest lands.

RANGE IMPROVEMENT AND IMPROVED METHODS OF HANDLING STOCK IN NATIONAL FORESTS

BY J. T. JARDINE

(Delivered before the Society February 29, 1912)

The paper presented by Mr. Kneipp has shown that the stock industry on National Forests produces an annual crop having a value estimated at $25,000,000, and that until in recent years the production of the forage crop supporting this industry was left to Providence and its utilization governed by the laws of chance—a lack of system in production and utilization which could not but result in waste. Even Providence can be aided in the amount, the quality, and the distribution of the forage produced, and it is surely no serious criticism of the stockmen to state that they could seven years ago and can still be materially aided in bringing about a system or systems of utilization which will consider the conflicting interests involved and will result in minimum waste.

The essential principles of the Forest Service management which have resulted in marked improvement in production and utilization during the past seven years are: Prevention of overstocking, which is the death knell of any range; (2) proper periods of use; (3) division of range between different classes of stock; (4) development of unused range; (5) improvement of watering facilities; (6) the creation of improved facilities for handling the stock; (7) improved methods of handling the stock, and (8) the allotment system of assigning the range which tends to fix responsibility for unnecessary damage. In 1907 investigative work was begun for the purpose of collecting experimental data to supplement experience as a basis for deciding the questions of carrying capacity, proper periods of use, how best to improve the quantity and quality of forage and the methods of handling the stock. Naturally, this work fell under two main subjects: First, how to produce the maximum value of forage crop. Second, how to get the greatest grazing efficiency per unit area in utilizing the forage produced. By virtue of the fact that grazing may be antagonistic to reforestation and to watershed protection, a third and perhaps the biggest problem of all arises: what portion of the forage crop produced can be utilized by grazing without jeopardizing the welfare of reforestation and watershed protec-

tion further than is justified by the comparative merits of the resources at stake?

The greater portion of range within National Forests was used for sheep grazing before the areas were set aside as forests. As a consequence of a help-yourself system of utilization during this early period, there resulted all stages of damage from slightly overgrazed to denudation. Obviously, to establish a condition of maximum forage production it must be accomplished either by seeding with introduced forage plants or by natural restocking with the most valuable forage plants already present on the ranges.

It was realized in the beginning that to scatter available seed over every area which was not producing a good crop of forage would result in large expenditures and might or might not result in an increase of forage. Any successful investigation of a problem which concerns *living organisms* must aim at isolating, if I may be allowed that term, the life history of the organism in question, its requirements of life, the factors which promote its development, and the factors which retard its development. The problem of seeding depleted ranges with introduced cultivated species was attacked by selecting a few localities as the basis of intensive investigations to determine for each of the cultivated species available the altitudinal range, moisture requirements, soil requirements, soil treatment necessary, ability to compete with native vegetation, ability to withstand grazing, the amount of seed necessary, the best time for sowing, and the cost per acre. To supplement the intensive work and have the tests cover the entire region within National Forest, a total of 449 small seeding experiments have been made under the direction of the Washington office, but under the immediate supervision of the local forest officers. These tests, averaging 4 acres in size, are distributed over 86 forests and cover an altitudinal range of 1,300 feet to 10,000 feet. Fifteen available species have been tested and, naturally, soil and moisture conditions, as well as amount of native vegetation, have varied. Prior to the initiation of an experiment a preliminary plan has been submitted for approval, and subsequent to seeding progress reports have been submitted for each project. From the intensive investigations it has been determined:

(1) That seeding with the cultivated species available should not be attempted within 1,500 feet of true timberline. Above this altitude a stand may be secured, but the temperature is so low and the growing season so short that the small amount of forage produced will not justify the expense.

(2) Below the altitude given the only areas which have the requisite soil and moisture conditions for successful seeding are those having a deep soil with considerable organic matter, such as are found in mountain meadows, moist park areas, meadow-like in character, and moist alluvial bottoms along streams. This is based upon actual measurements of the moisture requirements of the available species as well as successful and nonsuccessful seedlings. No forage plant has yet been found which can be successfully introduced on the large areas of dry hillsides.

(3) Even on areas where the requisite soil, moisture, and altitudinal requirements exist it is not economically possible to seed cultivated species where the native vegetation is dense. Cultivated plants can seldom replace a vigorous stand of native vegetation. A small amount may grow, but not sufficient to justify the expense of seeding unless the area is cultivated.

(4) Except in the Southwest, the seed should be sown in the fall; October is the most satisfactory month. In the Southwest May is the best time, owing to the long period of drought in the spring and to the rainy season occurring between May and September. It is highly important that some inexpensive soil treatment be given to cover the seed. Trampling in with sheep is satisfactory, or the use of a brush harrow will serve.

The compiled results of the 449 small tests substantiate these conclusions.

There still remains the task of completing a study, already begun, to classify in terms of native vegetation the areas upon which seeding to cultivated species is economically possible and the species to sow. There also remains the possibility of introducing native species, which are not now under cultivation, into new localities. This may be possible by collecting the seed in the native habitat, and later growing the plant at forest experiment stations or elsewhere under cultivation, in order to produce seed at a cost which would not be prohibitive to distribution.

At best the acreage suitable to the introduction of cultivated forage plants is small compared to the total acreage of range. Consequently success in improving forage conditions depends largely upon protecting the best forage plants already present sufficient to secure natural reseeding and reproduction of those species. To accomplish this end and at the same time utilize the forage to the fullest possible extent, it is necessary to know the absolute requirements of the vegetation we wish to reproduce, and then adjust grazing so as to meet those requirements which must, consciously or unconsciously, be acknowledged in any successful system of grazing.

A very intensive study was undertaken to develop such a system of grazing upon high mountain range, which is the most difficult type of range to maintain in condition of maximum productivity, due to short growing season, low temperature, and excessive demand for such range. The essential points determined were:

(1) On badly overgrazed areas, where herbage has been seriously weakened by continuous early grazing, at least two and in some cases more than two seasons of protection are necessary before a normal crop of seed is produced.

(2) That even on our highest ranges the seed crop is practically matured by September 1, while the grazing season lasts ordinarily to September 15 or October 1.

(3) After seed maturity the air-cured forage is palatable and nutritious, and, so far as reproduction is concerned, it is better to utilize this forage by close grazing than to leave it ungrazed, as the grazing aids in scattering the seed and trampling it into the ground.

(4) For the two seasons following the production of a good crop of seed it is essential to graze only in the late fall, and then carefully and only moderately heavy, due to the fact that the newly established seedlings are readily injured by trampling. Besides additional seed is thereby matured to insure abundant reproduction.

From these data can be deduced two principles which are the basis of judiciously deciding periods of grazing. First, that it is impossible to keep a range in condition of maximum productivity if it is close grazed during the first half of the grazing season year after year. Such practice gradually weakens the plant constitution by preventing the development and storage of the necessary amount of reserve food. Second, where sufficient permanent watering places exist, it is possible to work out a rotation system of grazing which will not only avoid impoverishing the plant constitutions, but will result in occasional natural reseeding—both without loss of forage utilization any year. On one forest such a rotation system was successfully practiced on ten sheep allotments last year. The principles are applicable everywhere and are gradually being applied.

In connection with the above intensive work there is also being gradually worked up complete information regarding the entire flora on our grazing lands. The work of the special men is being supplemented by local forest officers, who are making plant collections for their respective forests. Since August 1, 1911, 2,500 specimens have been received for identification and economic notes. In this way it is hoped to develop a knowledge on the part of the supervisors, rangers, and permittees of the

distribution, comparative value, and growth requirements of the plants which make up the forage crop on their respective forests. With this knowledge there will be increased possibility of more intensive utilization without destroying the thing we must protect.

In proposing any change in the existing methods of handling the stock after they are on the range, it is necessary to keep in mind its effect upon the vegetation, effect upon the animal, and its practicability from the standpoint of the stockman. The vegetation and the animals again are living organisms having inherent requirements and characteristics of life. A thorough understanding of these natural forces as they exist under range conditions, in conjunction with a first-hand knowledge of handling stock, is the best foundation for building up an efficient system or systems of handling. To facilitate such a study for sheep, a coyote-proof pasture, including 2,560 acres of typical mountain range, was inclosed. For five successive seasons a band of sheep has been grazed in the inclosure, free from annoyance of any kind. During this period a careful study has been made of the actions of the sheep, growth of sheep, loss of sheep, to some extent wool growth, carrying capacity of range, and cost of handling under this approximately ideal system, as compared with results on corresponding points under existing systems of handling on the open range. This study necessitated several years of test, but, based upon the data collected, it is now possible to safely state to sheepmen that if the sheep are kept constantly on the range instead of being driven back and forth to and from a central camp; if allowed free, quiet open grazing rather than close herding and worry by dogs; intermittent use of areas instead of constant use until the vegetation is eaten into the ground, the result will be a five to ten pound increase in the weight per head of sheep; a smaller number of unmarketable "dogie" sheep; increased wool growth and an increase in carrying capacity of range of from 10 per cent to 50 per cent, depending upon the intensity of bad management on previous occasions. A similar study has been in progress two years to try and improve existing methods of handling ewes during the lambing period.

That there is possibility of increasing the carrying capacity of range as well as possibility of increasing the annual crop of sheep, their weight and wool growth is evidenced by the fact that at present the lamb crop varies in any one year from 60 per cent to 115 per cent of the total ewes, with an approximate average of 75 to 80 per cent; the approximate variation in the weight of lambs of the same age and breeding is 25 pounds; the approximate variation in wool crop is from 5 pounds to 11 pounds, and there is a variation of as much as 35 per cent in the

amount of range required per head of sheep under different herders. That improvement along these lines can be brought about and is being brought about is evidenced by the following results cited from one forest. During the season of 1910-1911 the number of sheep on the Madison Forest was increased from 90,000 to 99,000 on the same range. The supervisor attributed this increase almost wholly to the fact that 50 per cent of the sheep are now never returned to a camp at night and are rarely molested by herders or dogs during the day. Formerly they were driven back and forth to and from camp and were herded in the true sense of the work. The lambs from bands handled in the improved way were eight pounds heavier and sold for $1 per head more than lambs of the same age and breeding belonging to the same company, but herded on range outside the forest. Other examples of the same facts could be cited.

For cattle the main problem of the Forest Service is to provide better facilities for handling. Mainly more and better watering places, drift fences, and holding pastures; these in conjunction with greater care in salting and more attention on the part of permittees—all to secure equal distribution over the range and prevent excessive congregation near water and other especially favorite areas.

The management of grazing upon National Forests which should be adopted in order to give reforestation, watershed interests, and the grazing industry the protection which the comparative value of these resources demands is a problem which must be approached sanely, without bias, and must be given thorough rather than a superficial consideration. Do sheep or cattle kill a few seedlings? Undoubtedly yes under any conditions. But this is not the question. The real problem is: What will be the net result even if a few seedlings are destroyed? This will take a period of at least ten years to determine sanely.

In some habitats grazing may—undoubtedly does—aid reproduction in getting started and in competing with other vegetation. In other habitats this is not true. Between the time of seed germination and the time the trees reach 5 feet in height many will be destroyed by grazing. During any period in the life of the tree grazing may be its protection against fire. What is the net result? My own idea is that if the range is protected as we wish to protect it against overgrazing and improper handling of stock the damage over the major portion of the forests will be negligible. Special areas, where reproduction must be had in minimum time, where we are prepared to adequately protect it, may require stricter measures.

Investigations for the purpose of determining the extent of damage to tree reproduction due to grazing have been in progress for two years. The essential points of the plan of investigation are:

(1) In each of a number of localities representing various conditions of habitat, take two small areas in every way comparatble to begin with. Fence one and keep it fenced indefinitely. Let the other take its chance under grazing. Map each area to begin with, showing all existing tree growth. Make a comparative study of the areas over a period of years and finally determine the comparative status.

(2) By means of many small permanent plats, located on the range to represent various conditions of habitat and grazing, make actual seedling counts with a view to determining the percentage of seedlings injured, the kind of injury and how it was inflicted, the season of greatest injury, the relative damage on the various forest types, relative damage done by different classes of stock, and the permanency and detrimental effect of various kinds of grazing injuries.

(3) To determine how much of this damage might be eliminated by more careful management or lighter grazing.

The results to date require more space than is justifiable in this paper and it is too early to draw conclusions.

In coöperation with the Bureau of Plant Industry, intensive studies are being carried on to determine ways of avoiding loss of forage by non-use of range due to stock-poisoning plants and loss of stock if they eat those plants, and in coöperation with the Biological Survey the problem of exterminating the prairie dog is being undertaken.

Granting that each of the lines of investigation discussed yields results of value, there will still remain the big problem of effectively incorporating the data collected into our grazing management. On our important grazing forests today perhaps 60 per cent of the valuable knowledge regarding the location, extent, and value of grazing lands by types is carried in the heads of supervisors, rangers, and other forest officers. They may leave tomorrow and take it with them. In order to increase the accuracy of this knowledge and place it in the most convenient form for future use, a map of reasonable accuracy should be made which will, as nearly as possible, be a graphic reproduction of the actual resources as they appear on the ground, but on a smaller scale than in nature, so that the value of each acre and its requirements of management as well as its relation to other acres can be more readily and efficiently determined. As more data are accumulated by investigation and as forest management and the management of grazing upon forests grows more intensive, this information becomes more and more a necessity in devel-

oping working plans which will put into application new data and improved methods, and result in a satisfactory, stable plan of improvement, of utilization, and of future investigative work.

The most satisfactory way of securing the necessary data and putting them in tangible form is by an intensive grazing reconnaissance survey. Such work was undertaken on four forests the past season. A total of 1,398,525 acres were covered, maps made, and economic notes collected on all grazing resources. In the growing of farm products the investigator may determine the most efficient agricultural crops and the most efficient management for various habitats and market conditions. It is then up to the farmer to classify his lands and conditions, so that he can apply the experimental data. In our work the Forest Service is in the dual position of investigator and farmer, and it is hoped that the work of classifying our lands can be continued to keep pace with other phases of the Forest Service work. It is the connecting link between the accumulation of data by special scientific investigation and the application of this data in actual practice.

SILVICULTURAL SYSTEMS FOR WESTERN YELLOW PINE

BY EARLE H. CLAPP

(Delivered before the Society March 21, 1912)

Western yellow pine is one of the most important National Forest trees, considering the large percentage of the National Forests on which it occurs, the immense areas in all parts of the West which it occupies exclusively or in mixture with other species, and the fact that it has been cut more extensively up to the present than any other National Forest tree. Accordingly the standardization of practice in the management of Western yellow pine is distinctly advisable in so far as the rather meager and fragmentary data available and the great diversity of conditions under which the tree is found will allow.

A statement of some of the characteristics of yellow-pine stands and of the tree, although commonly known, will make clearer the basis for the conclusions reached regarding silvicultural treatment.

In general, Western yellow pine is found either in pure stands or forming a large proportion of the mixture with other species. It commonly occurs as an open, irregular, uneven-aged forest, with rather a marked tendency toward even-aged groups, usually of small size; in the Southwest, for instance, of from 2 to 20 trees; in California, not usually exceeding an acre in extent; in western Montana and Idaho, rather frequently in favorable situations such as the bottoms of narrow draws, of considerable extent of mature timber. Frequently on areas of considerable size the distribution is by single trees, and groups are ordinarily connected by scattered individual trees. In the Black Hills, due to repeated fires, there are large bodies of relatively even-aged timber. In general, there is a good representation of all-age classes, considering the number of classes ordinarily required in a yellow-pine rotation of from 180 to 200 years as not more than 3 or 4. The presence of decadent and mature trees is almost universal, as is also reproduction, which commonly occurs in groups or patches in openings or partially under the shade of the parent trees. Under the most adverse conditions, reproduction may be secured only at long intervals under a combination of favorable conditions.

Except as a seedling, the tree is decidedly intolerant. For the seedling, either a certain minimum of soil moisture in the upper layers of

the soil must apparently be present, or a certain amount of shade and protection is necessary. One or the other of these conditions is essential to reproduction. Injury from early fall and late spring frosts is sometimes of vital importance in preventing reproduction.

Before taking up a consideration of silvicultural systems which should be used in the management of yellow-pine stands, I desire to emphasize some considerations which should, in general, apply regardless of the system adopted.

Since our stands are generally characterized by mature and decadent trees, and it is reasonably certain that growth, as a result, is largely or altogether offset by decay, our primary object, regardless of the system, should be a light cut to remove the material which will not live or thrive until a second cutting, provided this is sufficient to warrant a practical operation. This will make it possible to cover rapidly the bulk of the yellow-pine type and make growth available, and also start reproduction. Furthermore, I am convinced that we shall need to go slowly about permitting second cuttings until practically all virgin stands have been cut over once. In general, the mature and decadent trees which would be taken out in a first cutting do not include more than two-thirds of the volume of the present merchantable stand, and in many cases even less.

Other things being equal, we should also, regardless of system, attempt, so far as possible, to locate cuttings in areas where the percentage of mature and decadent timber is unusually large and where there is good advance reproduction.

On many of the National Forests where yellow pine has been cut heretofore the selection system has been followed. Approximately two-thirds of the volume of the merchantable stand has been removed. A tentative rotation of from 180 to 200 years has been considered, with cutting cycles of from 40 to 60 years. The modified group form of the selection system has been followed in California, advocated in parts of the Southwest, and clearly recognized in the Northwest. In parts of the Southwest and in the Black Hills the shelterwood system has been followed, the first cutting taking out from 60 to 70 per cent of the stand, with the idea of returning in from 10 to 20 years for the remainder after reproduction is secured.

Using as a basis the moisture or shade conditions necessary to secure natural reproduction, yellow-pine stands may be divided into three classes, each of which should be handled differently:

1. A comparatively large proportion of the yellow-pine region in which moisture and other conditions are so favorable that natural reproduction is reasonably certain, even though cutting is not designed pri-

marily to secure it. Here a modification of the selection system in which small groups are treated much the same as individual trees should be used. Resulting even-aged groups should increase volume production.

2. A smaller proportion of the yellow-pine region, including dryer portions of the Southwest, parts of California, where the chaparral question is serious, and possibly the pumice soils of the eastern Cascades, in which, in spite of adverse moisture and temperature conditions or the presence of brush, it is reasonably certain that natural reproduction can be secured by careful cutting. The method of cutting must accordingly be designed almost altogether by preserving favorable moisture conditions or by shading out chaparral, or both, to secure reproduction. The trees left must be as evenly distributed over the area as other conditions will allow. Since full light is necessary for the thrifty growth of saplings, the parent trees must be removed as soon as possible after reproduction is secured, resulting in a primitive application of the shelterwood system, even-aged stands and the possibility of much greater volume production than at present.

3. Areas of considerable extent in exposed situations and along the lower border of the type, where conditions are extremely adverse and where natural reproduction cannot be expected to follow any system of cutting. No cutting should be done until advance reproduction is present, and it should then take the form, either selection or clear cutting, which the quantity and distribution of the advance reproduction indicates.

Mr. Pearson, as a result of investigations on the Coconino Plateau, found that yellow-pine reproduction in general occurs outside of the protection of the parent trees only when there is sufficient moisture in the surface layers of the soil, and that either protection or moisture is necessary for reproduction. Observations indicate that through a large part of the yellow-pine belt, Class 1, moisture conditions are sufficiently favorable so that the overhead shade of the parent tree is unnecessary. This holds true in much of Montana and Idaho, Washington and Oregon, California, and even in parts of the Southwest.

The following description of a modified form of the selection was given before the Society on March 10, 1910, by Mr. Graves in a discussion of the selection system (Proceedings, Vol. V, No. 1):

"This tentative development of the selection system is applied in a number of special forms in Europe. In general, the tendency is to transform the forest to the group selection form in which each age class occurs in groups instead of in the single-tree arrangement. The groups

vary in size from 50 feet to several hundred feet across, are irregular in form of area, and their location irregular in relation to each other, but the aim is to secure an equal aggregate area of each age class in each compartment."

This form of the selection system, which merges into clear cuttings in groups, and is sometimes called the patch system or the group system, is the form intended for Western yellow pine. The modified form should give good results with such an intolerant tree as yellow pine. Each group, while protected and shaded to some extent from the side, has full sunlight from above, and the size of groups can be so regulated as to secure best results in reproduction and a maximum of growth and reproduction. The presence in virgin stands of even-aged groups and a good representation of age classes will assist greatly in the introduction of this system.

While it is probable that good results could be secured by the use of the shelterwood system, it does not seem advisable under present conditions and at the beginning of systematic management to attempt to change over to even-aged stands the immense areas of uneven-aged yellow-pine forests under our control.

In the application of the principles of the selection system to actual operation in Class 1 all decadent trees, those declining steadily in value, should be cut, and mature trees, those which are practically at a standstill, unless they are clearly needed for seed or protection. While it will, of course, be impossible to transform an irregular stand at once into an ideal form, a much more distinct recognition of the group formation should be given than heretofore. The determination of the proper size for openings under varying conditions will be exceedingly difficult, and until exact experimental results are available it will be necessary to depend upon observations in virgin stands and in private cuttings. In general, the size of openings and the resulting size of groups must decrease as conditions become adverse. Under no considerations should openings be large enough to enlarge existing parks or to create parks, or to allow the encroachment of chaparral or brush to the exclusion of reproduction. Upon comparatively small areas surrounded by Class 1 conditions, it may be necessary, because of adverse conditions, to remove only individual trees. Groups of advance reproduction should be uncovered when from the best observations available it seems probable that this reproduction will thrive, and that on a whole a greater production will be secured than through leaving surrounding trees. Since the aim should be to secure an equal aggregate area for each age class within each compartment, the approximate amount of each cut will become self-

regulating as soon as the number of cutting cycles are also determined. The first cut may be irregular, and should not, even at the expense of irregularities to be corrected in the future, remove too great a part of the cover or too large a percentage of the merchantable timber. Two-thirds of the volume of the merchantable stand should for the present represent about the maximum.

The cutting in Class 1 of even-aged mature groups exceeding the ideal group in size will, in most situations, tend to formation of even-aged reproduction; but these stands occur upon comparatively small areas, and even though all of the remaining trees are removed in a second cutting, the influence upon the periodic cut for an entire working circle should not be great.

Although it is still necessary to judge entirely from the diameter growth of individual trees, both yield and quality growth tables being unavailable, a tentative rotation of from 180 to 200 years seems advisable. The proper rotation will produce the maximum amount of the class of material desired, which will in most cases be saw timber.

Cutting cycles, not exceeding 50 years, seem to be about right under present conditions. For many obvious reasons our tendency should be, so far as possible, to make them short rather than long, and this tendency will reduce the amount of material taken out at any one time. This technical need must be balanced in all cases with the need for cutting a sufficient amount of material to warrant lumbermen to operate, to secure reasonable stumpage prices and favorable contract conditions.

In a Class 2 area on the Coconino Plateau, Mr. Pearson, of the Fort Valley Experiment Station, found that young growth, both in virgin and cut-over stands, is in groups on the north and east sides of the parent trees, usually no nearer than 5 to 10 feet from the base of the tree and extending out to the north and east about 20 or 30 feet. He found that frequently these groups are sharply outlined, with scarcely a seedling beyond well-marked, definite limits. He found that the protection which is necessary to start reproduction is too great for the thrifty growth of the sapling.

Practically all of what is now the Prescott National Forest has been cut over lightly several times in a manner which approaches roughly the shelterwood system. Very little of the old stand now remains. Reproduction is generally good, and in places the young growth is very dense. Climatic conditions in this forest, and especially precipitation, are not particularly favorable.

Mr. Pearson has found from a study of old cuttings that, in general, under adverse conditions, heavy cutting, so far as natural reproduction

is concerned, has proved disastrous, and that under adverse conditions reproduction seems to be best when the natural conditions of the virgin forest are but little modified.

These facts all indicate, under the conditions of Class 2, a light preliminary cutting, which, in order to secure the maximum of reproduction, will leave the remaining stand well distributed, and a second cutting after reproduction is well established to free the young trees and provide for thrifty growth. This is a primitive application of the shelterwood system.

It is probable that some degree of success, and possibly yields equal to virgin stands, could be secured even under Class 2 conditions by the regular form of the selection system. The main objections are the need for shelter to get reproduction, and the need for removing it in a short time to get good growth. Large production in yellow pine because of its intolerance must come from even-aged stands or even-aged groups, and it is doubtful if, under the condition of Class 2, groups can be made large enough to secure good growth and at the same time get reproduction.

Theoretically, under the shelterwood system the stand is removed gradually by a series of thinnings. Each thinning extends through the stand and gives it a uniform character. The new stands, which are essentially even-aged, start under the shelter of the trees left, which, in addition to furnishing seed, act as protection. In European practice the whole stand is usually removed within a period of 10 to 40 years.

In the practical application of this system to the Western yellow-pine stands of Class 2, the aim in the first cut, in order to secure reproduction, should be:

1. To make the cut as light as practical considerations will allow (never more than two-thirds of the virgin stand) and to secure as even a distribution of the remaining stand as is possible and practicable.

2. To remove, so far as consistent with this principle, mature and decadent trees, and those suppressed, injured, diseased, and defective trees which are a menace to the stand or which will not live until a second cut, and to leave sound, thrifty, wind-firm trees capable of seed production and growth.

The recognition of the group tendency of yellow pine should be confined to uncovering groups of advance reproduction and to removing even-aged groups of mature or decadent timber, where single trees left would probably be wind-thrown or cannot be left for some other valid silvicultural reason. Great care should be taken to keep openings small.

The time for the removal of the remaining stand must be left largely to the future. It is probable that market conditions will not be sufficiently favorable to warrant more than one cutting. Silviculturally, it should probably occur in from 10 to 20 years, after reproduction is well started. Actually, it may be considerably delayed, and the time finally selected will be a compromise between the following conditions:

1. The advisability of cutting over the great bulk of our over-mature stands before beginning extensive second cuttings.

2. The desire to secure the maximum growth from the material to be cut with the least damage to the young stand through shading.

3. The regulation necessary and the demand for timber.

A rotation of approximately 200 years, as in Class 1, will probably be required.

In parts of California, where moisture conditions are favorable but the ground is occupied with chaparral, and reproduction will accordingly be difficult, the chief aim of the first cut should also be to secure reproduction. Here, in order so far as possible to shade out the intolerant chaparral, the trees left should be well distributed, and a decision made later depending upon the existing conditions and the results secured as to whether the shelterwood or selection system be finally adopted.

While the shelterwood system is undoubtedly indicated in the Black Hills because of the even-aged character of the present stands, it is probable that management under the selection system would give good results, because the distribution of the precipitation is such that the conditions for reproduction are favorable.

In the third class conditions are so adverse that reproduction cannot be expected to follow any system of cutting. Such areas are common along the lower edge of the type on exposed southern and western slopes, and on particularly poor sites. In addition, it probably includes a part of the forests of the eastern slope of the Sierras and a large part of the chaparral areas in southern California. This class is characterized by light stands offering little protection. Reproduction is secured only under combinations of favorable conditions which occur infrequently, and which cannot be foreseen. In this class no cutting should be allowed until advance reproduction is secured. The system then followed should depend upon the quantity and distribution of the reproduction and the age and condition of the existing stand. Where reproduction comes in evenly over large areas, the cutting of the original stand may be comparatively heavy or clear. If, however, reproduction is in scattered groups or occurs only as scattered seedlings, the cutting

(selection) should do little more than remove the mature and decadent trees under the protection of which the reproduction started. After planting methods have been developed, it will, of course, be possible to cut clear and plant.

Modifications in the system used in pure stands may be necessary when other species are found with yellow pine. The common mixture in the North and Northwest is, on cooler exposures, chiefly with Douglas fir, white fir, and occasionally lodgepole pine, and on the warmer exposures with larch. White fir of merchantable size is usually defective, and Douglas fir, because of mistletoe, may not produce good stands. Furthermore, the Douglas fir is outside of the region of its best development, and while valuable locally, is of secondary value for the general market. Present markets do not recognize the intrinsic value of larch.

In California the mixture consists of white fir, incense cedar, and sugar pine, the first two very defective, and under present conditions almost a drug on the market; Douglas fir of secondary value because of competition with the fir of the Northwest, and sugar pine more valuable than the yellow pine itself. The percentage of white fir and incense cedar reproduction, already large, is probably increasing in virgin stands. In the middle Rockies and the Southwest, Douglas fir and white fir commonly occur in mixture on north slopes and at higher elevations. White fir is defective and inferior.

Where there is danger that inferior species will crowd out the more valuable yellow pine, an attempt should be made to reduce their proportion in the stand by cutting out seed trees so far as possible, and where inferior species are also defective, an attempt should be made, at least in selection stands, to reduce their rotation to one which will produce sound timber.

In stands where the percentage of yellow pine is small, even though it is unquestionably the best species, the inferior species, or those of secondary importance, should not, unless other silvicultural reasons make it necessary, be cut heavily except when by so doing it is reasonable to suppose that the percentage of yellow pine can be increased. Sugar pine in California stands may be favored by keeping openings small.

The probability that a proper mixture of tolerant species with yellow pine may be of a distinct advantage must also be recognized.

Consideration of our methods of handling yellow pine stands has emphasized the need for more exact silvical and yield data for stands under different systems of management and varying conditions. These data may be obtained from timber sales, or in part from cuttings on private lands, or even from virgin stands. By taking advantage of National

Forest timber sales, it should be possible, by varying the method of cutting on areas of sufficient size to give conclusive results in accordance with a comprehensive plan, to determine the yield which may be expected under different systems.

The selection and shelterwood systems should receive the maximum consideration. From yield tables so obtained it will be possible to decide the proper rotation under which yellow pine, under varying conditions, should be managed in order to secure the maximum volume production of the kind of material desired. We should have data also to show growth in quality.

For the selection system, it will be necessary to determine the best size for groups under varying conditions, considering both reproduction and yield, and the best cutting cycles. For the shelterwood system, the number of the cuttings necessary for best results and the approximate extent to which the stand should be opened under each, with particular reference to the distribution of seed and shelter trees in the first cuttings, should be determined.

The conclusion of experiments will obviously require many years. In the meantime, a number of studies along the lines indicated above can be conducted which should give results of the greatest benefit for immediate application.

STATE FORESTRY PROBLEMS

BY A. F. HAWES, STATE FORESTER, VERMONT

(*Contributed*)

The Proceedings of the Society of American Foresters have contained a great many articles bearing on the management of the National Forests, which must be of great value to the foresters entrusted with their administration. Thus far comparatively little has been written bearing on the problems of State forestry, and since I believe that the most marked development in forestry work of the next decade will be accomplished through the various State governments, I propose in this paper to suggest a few of the problems confronting the forester in State employ, with the hope that some discussion on this side of the profession may be aroused.

Since my experience in State forestry work has been confined to New England, the conclusions reached necessarily apply primarily to New England, although many questions of policy apply equally well in other sections of the country. The main problems confronting a State forester group themselves naturally under: 1, Protection; 2, Education; 3, Silviculture; 4, Utilization; 5, Policy. These problems naturally overlap, and perhaps it would be more correct to speak of the first four as the various subjects with which State policy deals. However, there are occasional questions which deal distinctly with policy aside from the other four subjects.

1. *Protection.*—The first essential for a State forester is to familiarize himself with the viewpoint of the people of his State. "Protection" to the average forester immediately suggests forest fires, patrols, lookout stations, telephones, etc. To the woodland owner of eastern Massachusetts it suggests gipsy and brown-tail moths, spray outfits, nest-collecting, etc., while to the timber owner of Vermont it is quite as apt to suggest the porcupine and a State bounty. The forester who tries to develop an ideal fire system in a State suffering little from fire without regard to other subjects in which the people are interested cannot meet with the best success. However picayune a subject may seem to him, he must give it due consideration if there is a popular interest in it.

(*a*) *Fire protection.*—The chief problem in this connection is in securing efficient fire wardens. Up to 1905 there was no good system of

wardens anywhere in New England. The law which was passed at that time in Connecticut provided for the appointment of a town warden by the selectmen with the approval of the State forester. This has enabled the forester to retain a good warden from year to year and gradually weed out the poor ones. In Vermont a law had been passed before the creation of the position of State forester making the first selectman fire warden of his town. This law has now been given four years' trial and it is safe to predict will never be a great success. The selectmen are usually elected for their business ability and as a rule live in the villages situated in the valleys. While they are often continued in service 20 years or more and are decidedly the best men for carrying on the town business, they are not well adapted to serve as fire wardens. I believe that about 30 per cent of the fire wardens elected in this way are efficient. In conversation with many of the selectmen on this subject I have found most of them favorable to adopting the Connecticut method of appointing wardens. Upon securing efficient wardens fire protection in our Eastern States is a simple matter.

The division of the expense between town and State is an important matter, but there can be little question that participation in the expense by the town is desirable, since it leads to economy which would often not be affected for the State. In Connecticut the expense is borne one-half by the town, one-quarter by the county, and one-quarter by the State. In Vermont* the whole expense up to 5 per cent of the grand list is borne by the town, the balance by the State. On the whole the latter arrangement seems preferable, since the poorer towns receive the benefit and the State is at less expense. Under this system during the four seasons—1909, 1910, 1911, and 1912—the State of Vermont has been obliged to help but one town for one fire.

Many questions arise in connection with the administration of a fire law which cannot be decided too arbitrarily. For example, if a fire warden of one town discovers a fire in another threatening his own should he give aid, and, if so, which town should pay the bill? There can, of course, be no question but that he should give immediate aid, notifying, if possible, the warden of the town in which the fire is. I believe that the bill thus incurred should be paid by the town in which the fire was situated. In most cases this opinion has seemed acceptable, but in one or two cases it has been impossible to force the benefited town to pay men from another town. The law should be explicit in this regard.

If men volunteer to extinguish a fire should they be paid the same as

* In Vermont the grand list is 1 per cent of all taxable property of the town instead of the total, as in most States.

those hired by the warden? If so, should a man be paid for fighting fire on his own land? Unquestionably, for support in future fires all bona fide fire-fighters should be paid whether they were hired by the town or had volunteered for the purpose before the arrival of the warden. The warden has the right, of course, upon his arrival to dismiss any men whom he does not wish to pay. Whether a man should be reimbursed for fighting fire on his own land is a very nice question. A man fighting fire in his house would not expect reimbursement from the city. Very few farmers extinguishing brush fires on their lands would think of charging the town for their time. The average lumberman who detailed his chopping or driving crew to fighting his own fires for a few hours would not expect to be reimbursed for such service. But if a fire occurred at a season when he had no men in the woods and he hired men especially for fire-fighting he would probably expect to be reimbursed by the town, and rightly so. If the lumberman is thus reimbursed should he not be for the time of his chopping or driving crew, and should not the farmer who extinguishes his own brush fire be paid by the town? On the whole it seems as though every one should be paid for fighting fire, even on his own land, unless he was responsible directly or indirectly for the fire. As an illustration of an extreme case of this kind, I will mention a bill which came up for my approval in connection with the reimbursement by the State of one town in 1911. A lumberman who owned the land on which the fire mostly occurred submitted a bill of approximately $100 for carrying men in his automobile back and forth to the fire for a week, charging at the rate of 20 cents a mile. The town paid this bill, together with others, amounting to about $1,300, but the writer disallowed 25 per cent of the automobile bill for reimbursement by the State.

The rate of pay that wardens and men employed in fire-fighting should receive is an important question. In Vermont wardens receive $2 per day and employees $1.50. These wages are interpreted as for a ten-hour day. In the better agricultural sections of the State it is almost impossible to hire men except through force at $1.50 per day, while in some of the more remote sections a wage of $1.75 per day might be an incentive for some of the men to set fire. On the whole it is safe to say that the wages paid for fire-fighting should be the same as those paid for work on the highways. In most sections of Vermont this is now $1.75, although $1.50 still prevails in some regions.

Whether it is desirable to require permits for the building of out-door fires, as in Massachusetts and Connecticut, depends very largely upon the local conditions. In manufacturing regions with a large foreign popu-

lation some such regulation is undoubtedly desirable. In agricultural regions occupied by native farmers such restrictions are very irksome and are not warranted by the number of fires started in this way. It would be well to allow the voters of each town to decide whether such a regulation should be made.

It is a question in Vermont whether in large lumber operations it is preferable to require the lopping of all softwood tops at a considerable expense or to encourage the practice of certain silvicultural measures, as the leaving of clumps of seed trees, etc. Under present market conditions it is hardly possible to expect both, and I believe the danger of fire in Vermont, at any rate, is hardly great enough to justify the expense involved by lopping all tops. It seems entirely feasible to have a law giving a land-owner, who believes that his property is endangered by a neighbor's lumbering, the power to appeal to the State forester for protection, and to give the forester the power upon such appeal to prescribe that all tops be lopped and possibly burned on a strip adjoining the complainant of such width as he might think necessary for a proper fire line.

The question is often asked, Which is more effective—lookout stations or patrols? While my experience with the former has been very limited, I believe that a patrol is more effective in a locality where there is a known danger of fire, as along a railroad passing through slash, places frequented by blueberry pickers, Sunday picnickers, etc, and that lookout stations are advisable in regions where the danger point cannot be predicted. A combination of the two is often advisable, especially so that the stations may be supplemented by a patrol in smoky weather.

Experiments have been made in Vermont during the season of 1912 with wireless telegraphy as a means of communicating with stations not equipped with telephone. Thus far, however, the advantages seem to be with the telephone.

The Federal appropriation of the Weeks law for coöperation with the various States in the prevention of fires has brought up a number of difficult problems. Among them the most interesting is the definition of a "navigable stream." As pointed out in an interesting paper written by Mr. Pettis and read before the Eastern Foresters' Association at the meeting held in New York in December, 1911, it is quite possible to claim that any stream is navigable which has been declared by a State legislature a highway for logs. It would perhaps be possible for Vermont to claim that the northwest third of the State, containing some of the best timber areas, should be protected under this law on the ground that the St. Lawrence is navigable, but since this is obviously contrary

to the spirit of the law we have thought best to be satisfied with the very material assistance the Government has given us in protecting the other watersheds.

The U. S. Forest Service has very properly ruled that moneys received under this law shall be expended to pay men employed in preventing fires and not in extinguishing them. This is making it possible to develop a system of fire prevention which was impossible in many of our States before the passage of the Weeks law. The question naturally arises as to how long the $200,000 appropriated will last, and whether Congress will provide further funds for this work. So long as the fund is handled as it is now being handled, under the direction of the present forest administration, there need be no question of its resembling the pork-barrel expenditures for rivers and harbors and Federal buildings. However, I believe that after the Federal Government has thoroughly demonstrated the effectiveness of such a system each State should assume its entire responsibility in the matter of fire prevention.

It has been very difficult to secure the right kind of men to carry out the work under the Weeks law, and it is practically impossible to get men to work a few days at a time when dry weather requires special protection. Since it is necessary to employ men for some weeks at a time, it has seemed best in Vermont to secure men of some forestry knowledge who could be employed during wet spells in some work acceptable to the U. S. Forest Service or in strictly State work, the pay being adjusted according to the number of days spent on the various lines of work. The difficulty in finding such men has emphasized the failure of our educational institutions to provide a training for the ranger type of man, who is willing to begin at $2 a day. While it is easy during the summer to secure any number of students of agricultural schools who have taken courses in forestry, those same men upon graduation can secure better agricultural than forestry positions. We have found that practically the only men with any forestry training available at this pay in the spring and fall are graduates of the Biltmore Forest School.

These patrolmen are employed during weather when there is no fire danger in mapping their districts (only about one-third of Vermont has been mapped by the Geological Survey), locating the important features of topography, roads, trails, telephone instruments, mills, and other points where men are available and where there is special danger of fire. After the completion of maps suitable for patrolmen or lookout watchmen their time is employed in locating and constructing trails. The Green Mountain Club is much interested in this work and, together with some of the timber-owners, is furnishing men in some localities to com-

plete the trails located by the patrolmen. These trails are laid out with an Abney level on a maximum grade of 15 per cent.

(*b*) *Protection from insects.*—As already intimated, the question is bound to arise in many States as to what policy shall be pursued in the war upon insects, what department of the State government the work shall come under, how it shall be organized, etc. There can be no question but that this work should be under a trained economic entomologist. Whether this official should be under the forest department or the agricultural department of the State government or entirely independent of either may be a subject for argument. The nature of the work requires that as insect pests multiply a considerable force of men be steadily employed for a number of months, if not the full year. In other words, the insect work offers more steady remunerative labor than any other lines of work of a State agricultural or forestry branch. This means that unless great care is used a political machine will result which will be the envy of the party out of power, and may as well prove an embarrassment to a non-political official as an asset to a politician. Of course, it is not necessary for the entomological work to be confounded with politics, but there seems to be a danger in that direction. As the insect work increases a greater and greater appropriation must be secured for it, regardless of other lines of work. This must result in the relegating of the educational work, either of the agricultural or forestry branch, to a position of secondary importance, which, to say the least, is unfortunate. If the insect work were under a department by itself the growing demands would be less apt to encroach upon the needs of forestry and agriculture proper. Certain kinds of insects, as the San José scale, which attack primarily agricultural crops, seem naturally to connect the entomological work with the agricultural branch; but most of the worst insects thus far common have been forest rather than farm pests. It does not, however, seem logical to divide the insect work between two or more branches; neither is there any appreciable economy in placing it under a branch already established. A capable entomologist must be employed in either case, and a corps of assistants, and the office work will be increased proportionally to the field work. On the whole it seems best both for agriculture and forestry and for the efficient suppression of insects that this work be under a State entomologist independent of either of these branches. Preferably he should hold his appointment from a non-political body as the experiment station or a commission. If some non-political commission could appoint the State forester, the commissioner of agriculture, and the State entomologist all on an equal footing it would perhaps be the best arrangement.

The suppression of fungus and other plant diseases hardly demands

the formation of a separate branch of the Government. The work is still in the experimental stage and very properly comes under the agricultural experiment stations. After effective methods have been developed the administrative work may be divided between the agricultural and forestry branch of the State government without resulting in any such confusion as joint entomological work might produce.

(*c*) *Protection from animals.*—Whatever scientific methods are adopted for the suppression of insects or fungous diseases the popular method of combating injurious animals will probably be through State bounty. The last legislature of Vermont reënacted a bounty of 30 cents a head on hedgehogs, or porcupines, because of the damage they do to standing trees, and $10 a head on black bears. It is certainly very doubtful whether porcupines do as much damage to the State as woodchucks or rats and mice, or whether the damage done by them greatly exceeds that done by the bounty-seekers through careless fires. The few black bears in Vermont probably do not do as much damage to property as would be brought into the State by sportsmen if the bears were kept for sporting purposes. However, views of this kind are heresy of the worst sort to advocate before a legislature, and the question is, What is the most economical manner of killing out pests like the porcupine? Probably no system of trained hunters under the State forester's office would accomplish the work as cheaply as under the bounty system, and certainly not as satisfactorily to the local inhabitants who want their share of the spoils. Theoretically it seems that each forest owner should be responsible for killing off his own porcupines just as each farmer kills the woodchucks in his fields. The large timber-owners cannot be relied upon to do this any more than they could to check the ravages of insects. In other words, while they are interested in the State's assuming the responsibility they do not believe it worth while for them to do it individually. The taxing the people of a whole State for local work of this kind hardly seems justified. If protection from animals is to be a public function the burden should at least fall heaviest upon those that are benefited. If it is impracticable to tax each land-owner for his proportionate share it is at least feasible that the local government or township bear a portion of the expenses just as for fighting forest fires. The bounties paid by Vermont on porcupines amount to several hundred dollars in some single townships. These towns might be obliged either to bear one-half of this expense or, as in the case of forest fires, to bear the whole expense up to a certain per cent of the grand list. Five per cent of the grand list, which in some towns would not amount to over $50, might well be the maximum required of any town for this purpose, just as it is in Vermont for fire prevention.

A SYNOPSIS OF THE RED FIRS

BY WILLIAM H. LAMB

(Contributed)

The red firs, distinguished by their large cones and crowded, quadrangular foliage, include noble fir (*Abies nobilis* Lindl.), red fir (*Abies magnifica* Murr.), and Shasta fir (*Abies shastensis* Lem.).

Many excellent descriptions of the red firs* are available, but full descriptions do not emphasize distinguishing characteristics, and the red firs do not seem to be clearly understood by all foresters. In consequence, much confusion exists on some of the National Forests of California and Oregon as to the distribution of these species, especially in the region of the Klamath Forest, where noble fir of the north is associated with red fir and Shasta fir of the south.

The factors which are of diagnostic value in distinguishing *Abies nobilis, Abies magnifica,* and *Abies shastensis* are:

1. The presence or absence of a longitudinal groove on the upper surface of the leaf.
2. The relative length of the cone-scale and the cone-bract.
3. The shape of the cone-bract.

The presence of a longitudinal groove in the upper surface of the leaf, shown in cross-section by fig. 5, is of great importance in distinguishing noble fir. As the leaves of both red fir and Shasta fir are not grooved on the upper surface (fig. 6), recognition of this distinguishing characteristic enables the observer to detect noble fir, even when the cones are not available.

The relative length of the cone-scale and the cone-bract is an important consideration. The cone-bracts of *Abies nobilis* are never shorter than the cone-scales, and those of *Abies magnifica* are never as long as the cone-scales, but the variation in the relative lengths of the cone-scale and the cone-bract of *Abies shastensis* is one of the chief causes of our incomplete knowledge of its distribution. When the cone-bracts are prominent and almost cover the surface of the cone (fig. 7), it is

* BRITTON: North American Trees; ENGELMANN: Trans. Acad. Sci., St. Louis, vol. III; ENGELMANN, in Brewer & Watson: Botany of Calif., vol. II; JEPSON: Silva of Calif.; MASTERS: Journ. Linn. Soc., April, 1886; SARGENT: Manual of Trees of N. A.; Silva, vol. 12.

FIG. 7.

FIG. 8.

FIG. 9.

PLATE II.—LAMB'S SYNOPSIS OF THE RED FIRS

RED FIR CONES, ONE-HALF NATURAL SIZE

FIG. 7.—*Abies shastensis*
FIG. 8.—*Abies nobilis*
FIG. 9.—*Abies magnifica*

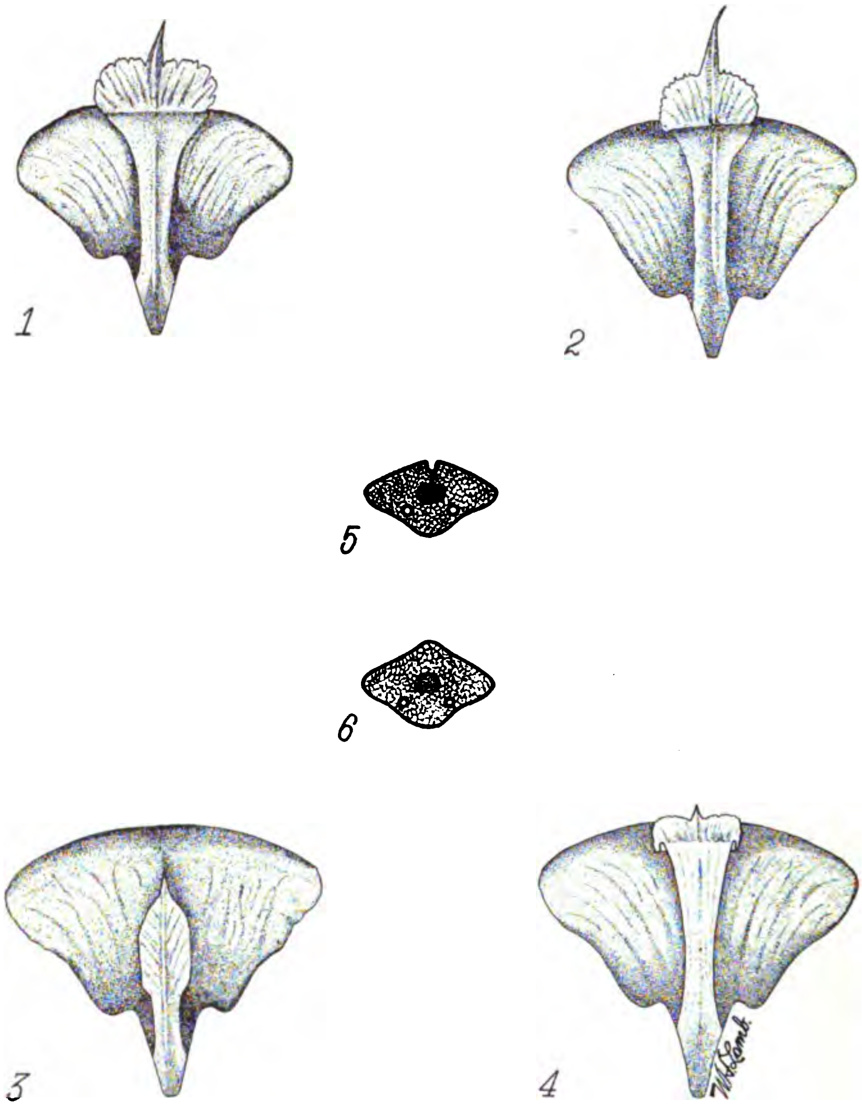


PLATE 1.—SYNOPSIS OF RED FIRS, BY WM. H. LAMB

CONE SCALE AND BRACT (× 1 1/5)
FIG. 1.—*Abies shastensis*
FIG. 2.—*Abies nobilis*
FIG. 3.—*Abies magnifica*

CONE SCALE WITH ABORTIVE BRACT (× 1 1/5)
FIG. 4.—*Abies shastensis*

DIAGRAMMATIC CROSS-SECTION OF LEAF (× 6)
FIG. 5.—*Abies nobilis*
FIG. 6.—*Abies magnifica* and *shastensis*

often reported as noble fir, and when the bracts are abortive and scarcely protrude (fig. 4), it is probably reported as red fir, extending the range of both noble fir and red fir at the expense of Shasta fir.

The conspicuous characters by which the red firs may be most conveniently recognized are set forth in the following key:

Bracts protruding (longer than cone-scales)
- Leaves grooved on upper surface.............. 1. *Abies nobilis*
- Leaves not grooved on upper surface.......... 2. *Abies shastensis*

Bracts included (shorter than cone-scales)
- Leaves not grooved on upper surface......... 3. *Abies magnifica*

The shape of the cone-bract has not been sufficiently emphasized as a distinguishing characteristic. The cone-bracts of noble fir (fig. 2) have larger and stouter points than those of Shasta fir (fig. 1), but in this case it is safer to distinguish these two species by the foliage distinction, which is positive and conspicuous. However, in the case of red fir and Shasta fir, where apparently there is no foliage distinction, the shape of the cone-bract becomes a very important consideration. The impression exists that the protrusion of the cone-bract is the character upon which *Abies shastensis* must be maintained as a species, but it is not the protrusion of the cone-bract, but its form, that should give to Shasta fir its specific rank. The cone-bracts of *Abies magnifica*, although slightly constricted at the base (fig. 3), are not enlarged, but acute at the apex, while the bracts of *Abies nobilis* and *Abies shastensis* are enlarged at the apex. With regard to the protrusion of the cone-bract, forms may be found which approach *Abies magnifica.* These intermediate forms (fig. 4), however, are probably produced by the abortion of the cone-bracts of *Abies shastensis*, and not by the lengthening of the cone-bracts of *Abies magnifica.* With regard to the shape of the cone-bracts, no intermediate forms have been observed by the writer.

The characters set forth in the following key, although not so conspicuous, are less variant, and will be found very useful in the identification of the red firs:

Leaves grooved on upper surface (fig. 5)
- Cone-bracts enlarged at apex (fig. 2).......... 1. *Abies nobilis*

Leaves not grooved on upper surface (fig. 6)
- Cone-bracts enlarged at apex (fig. 1)......... 2. *Abies shastensis*
- Cone-bracts acute at apex (fig. 3)............ 3. *Abies magnifica*

1. *Abies nobilis* Lindley. Noble Fir. A tree attaining a height of 90 meters and a diameter of 3 meters. Leaves grooved on upper sur-

face; on lower branches 2 to 3.5 cm. long, flattened, rounded, and notched at apex; on upper branches 1 to 2 cm. long, thickened, 4-sided, erect, incurved, crowded, acute at apex. Cones 10 to 15 cm. long, purple or brown, puberulous, with excerted, reflexed, long mucronate, fimbriate bracts.

2. *Abies shastensis* Lemmon. Shasta Fir. A tree reaching a height of 60 meters and a diameter of 1.2 meters. Leaves 2 to 4 cm. long, not grooved on upper surface; on lower branches flattened, rounded, or bluntly pointed at apex; on upper branches much thickened, 4-sided, erect, incurved, crowded, acute at apex. Cones 13 to 15 cm. long, purple or yellowish brown, puberulous, with slightly excerted or conspicuously excerted and reflexed, spatulate, short mucronate, laciniate bracts.

3. *Abies magnifica* Murray. Red Fir. A tree reaching a height of 90 meters and a diameter of 3 to 5 meters. Leaves 2 to 4 cm. long, not grooved on upper surface; on lower branches flattened, rounded and bluntly pointed at apex; on upper branches much thickened, 4-sided, erect, incurved, crowded, acute at apex. Cones 15 to 25 cm. long, puberulous, dark purplish brown, with included bracts which are constricted at the base, slightly serrulate above the middle, acute and short mucronate at apex.

NATURAL VERSUS ARTIFICIAL REGENERATION IN THE DOUGLAS FIR REGION OF THE PACIFIC COAST

BY THORNTON T. MUNGER

(Contributed)

The comparative merits of artificial and of natural reforestation have long been a topic for discussion among foresters, and in any forest region may be found adherents of each side of this question. There are a number of general principles which must be taken into consideration in deciding whether a certain species which might be managed by either method should be managed by one or the other. In most forest types careful balancing of these factors will indicate clearly which of the two methods is preferable. Chief among them—and they are too well known to need more than mention—are the natural reproductive vigor of the species, its ease of establishment by artificial means, the surety with which it will become established from seed trees, the value per acre of the seed trees that must be left.

In the Douglas fir region of the Pacific Coast—that is, the region west of the Cascade Mountains in Oregon, Washington, and British Columbia—there are many other factors which come into play and which greatly complicate the problem. In this region growth is so enormously rapid, the virgin timber is so large, the stand is so heavy, and logging methods are so unique that this question in this region has many puzzling features. It is, moreover, a problem which is rapidly coming to the front and should be solved.

In Mr. Kirkland's and in Mr. Greeley's very able articles in recent numbers of the Proceedings * artificial reforestation is accepted as the better technical method to use in this region, but there are many sides to the question, and I desire to bring out some of the considerations which point to the desirability of natural regeneration.

A brief résumé of the character of the forests of this region and of the silvical characteristics of Douglas fir may perhaps be of interest here to those who are not personally familiar with the Pacific Northwest.

Douglas fir, in the region under discussion, is a tree which will do well under a great variety of conditions. It thrives almost equally well at

* Proceedings of the Society of American Foresters, vol. VI, pt. 1, pp. 32-36, and vol. VII, pt. 1, pp. 48-50, respectively.

sea level and at 3,000 feet in the Cascades, though its rate of growth is closely connected with the humidity and the length of the growing season. It endures sandy, clayey, and rocky soil, reaching its optimum development only on deep porous soils. It grows well on hot south slopes, in cool ravines, or bleak situations. In fact it is not a fastidious tree and does not require coddling in the hands of the forester.

There are but few sources of injury to which this tree is subject, and none of them are particularly serious in normal stands previous to maturity. Old trees are apt to be affected with "conk" or "pipe rot" or "white-pitted rot" (*Trametes pini*), and this causes many of them to be broken off or disfigured by the wind; but this injury is not common in immature trees and is in fact rarely found in trees up to the time they are 100 years old.

Douglas fir is on the whole a wind-firm species, as the thousands of solitary "cull trees" still standing on the lands logged over in the past 30 years in western Oregon and Washington testify. Its great height and the moist loose soils on which it frequently grows, however, subject it to severe tests, to which it gives way at times, and this has given rise to the opinion occasionally advanced that isolated trees are not windfirm.

Fires in Douglas fir forests are apt to become crown fires, and as such are extremely destructive, but fire is not apt to run in Douglas fir forests unless the surface has become exceptionally dry and the climatic conditions are exactly favorable. Surface fires do a relatively small amount of damage to Douglas fir, since the bark is thick and corky, the roots are well imbedded in mineral soil, and the crown does not extend to the lower part of the tree.

It is, however, particular as to its supply of light; reproduction will start, but will not survive in the shade of the normal virgin forest, and though this tree is able, in western Washington and Oregon, to form extremely dense stands, those members of the stand which do not get a liberal supply of top light quickly die. Douglas fir seems never to suffer from too much light, and trees which grow singly or which have been isolated by the removal of their neighbors are particularly thrifty.

The reproductive characteristics of Douglas fir are one of its great assets from a forester's standpoint. It produces a good quantity of seed every two or three years, and while hardly as profuse a seed producer as lodgepole pine, for example, it ranks well in this regard. Its seed is light, and owing to the great height of the trees is wind-disseminated to a great distance. It is, moreover, scattered through a period lasting several months.

While it seems to be extremely advantageous for the seed to have mineral soil upon which to germinate, this is not absolutely essential. The seedlings grow two or three inches the first year and three or four more the second, and by eight years of age they are as many feet high. The luxuriant growth of bushes and herbage which usually spring up on burns in this region is a serious enemy of Douglas fir reproduction, but except when the brush is extremely rank, as it is after repeated surface fires, the young trees usually conquer it in half a dozen years.

The commercial forests of western Washington and Oregon, up to an elevation of 2,500 to 3,500 feet, consist to a large degree of a stand of Douglas fir, in which there is usually a small admixture of western hemlock, western red cedar, grand fir, and occasional other species. This stand is ordinarily fairly even aged, very dense, and consists of large trees of fairly uniform size. The majority of the virgin stands average from 50,000 to 150,000 feet B. M. per acre, and are composed of trees which are from 3 to 6 feet in diameter and over 200 feet high. The stands are, therefore, under normal conditions extremely dense and the vigor of the trees and the accompanying undergrowth of shrubs and ferns is tropical in its luxuriance. When a forest of this species comes to maturity and begins to decline, usually at an age of 300 to 350 years, the veteran trees one by one fall a prey to fungi or accidents, and the stand very gradually becomes less and less dense and takes on the appearance of an over-mature, disintegrating forest. But since Douglas fir is a tree which reaches its best development only in even-aged pure stands, is but intermediate in tolerancec, and does not reproduce successfully under the shade of the mature timber, an undergrowth of Douglas fir does not spring up to take the place of the original stand, for there is not sufficient light, but instead an undergrowth of western hemlock, grand and amabilis fir and western red cedar (all tolerant species), which have seeded in from the occasional old trees of these species and which are almost always found in mixture with the Douglas fir, occupies the ground and rapidly pushes up under the half shade of the veteran Douglas firs. The result of this process is the replacement of the pure even-aged Douglas fir stand by a somewhat uneven-aged and irregular forest of inferior species. It is very clear that on many thousands of acres in western Washington just this transformation of the forest type has taken place. That this process has not effected the conversion of all the forest lands of this region from pure Douglas fir (clearly a temporary type) to the mixed forest of tolerant species, hemlock, cedar, and grand fir (the ultimate type), is due to the intervention of forest fires, which have undoubtedly run over these mountains for

centuries. Where fire has cleared off a tract of virgin timber, Douglas fir has its opportunity to reproduce itself, and unless the burn is too remote from a source of seed it is usually very successfully restocked with a dense stand of Douglas fir seedlings. It may be said, therefore, that the pure stands of Douglas fir are found where forest fires have cleared off the former forest generation and assisted Douglas fir to re-establish itself, and that where fires have not run in the past few centuries the virgin forest has degenerated into an uneven-aged stand of tolerant species.

Douglas fir forests are logged almost wholly by the use of steam donkeys, in connection with logging railroads. In spite of the fact that there is a great deal of timber per acre the cost of logging in this type is ordinarily high. With timber of the height and density of the Pacific Coast fir and with the use of donkeys, the only practicable method in cutting is the clean-cutting method. This is exactly the method which the silvical conditions dictate, for practically all of the trees in the stand are of merchantable size; there is no young growth to save, and an even-aged stand of pure Douglas fir is desired.

After the logs are yarded out, the tops, cull lengths, and brush lie heavy on the ground, often uniformly 4 or 5 feet deep, so that broadcast burning is the only practicable method of disposing of this debris. This is done in the fall or spring at such a time that the surrounding green woods may not be endangered, and yet at a season when the brush will burn up as cleanly as possible. This practice is essential both in order to remove the menace of the unburned slash and to expose the mineral soil for the reception of seed or young trees. Broadcast burning is necessary, whether the second crop is to be secured by natural or artificial means.

Now we come to the particular topic of this article, Shall the forest be reproduced by natural or by artificial methods? Let us consider first what are the steps by the latter method. The forest is first cut off absolutely clean down to as low a diameter as the trees are merchantable, and the few small trees which cannot be utilized are usually broken off by the falling of their larger neighbors, so that the area is left very bare. The brush then having been burned broadcast, the area is ready to be artificially restocked. This may be done in either of three ways: by planting, by sowing seed in prepared spots, or by sowing broadcast. Planting can be done in the most favorably situated localities in such a way as to be successful for $9 per acre, but the cost will be greater when the transportation charges for plants and labor are high. The cost per acre on an average accessible tract in this locality will be about

as follows, assuming that 888 trees are planted per acre—*i. e.*, that they are spaced 7 feet by 7 feet:

Cost of 1–1 transplants per acre	$3.50
Cost of transporting trees to planting site per acre	.75
Cost of setting out the plants per acre	6.00
Total per acre	$10.25

The practicability of planting is, of course, contingent upon the possibility of securing plants. For large operators or for the Forest Service, which raises its own trees, the cost of the trees is lower than it would be for the small operator who has but a small tract to reforest each year and must buy his planting stock of a commercial nursery, and must run the risk of not being able to get any locally grown nursery stock when he wants it.

The experiments so far conducted indicate that broadcast sowing of Douglas fir is not to be advised for this region, even though it has the advantage of a very low labor cost. At times this method gives results, but it seems to be uncertain, and the large quantity of seed necessary to get a stand of seedlings more than offsets the low cost of labor when compared with the seed-spot method. It is, therefore, not a method which commends itself for use in this locality so long as there are other better means of starting a second crop.

Sowing the seed in prepared spots will from present evidences be successful in favorable situations in favorable years. Seed planted in this way is in a much better position to compete successfully with rank brush and herbage than broadcasted seed. It is not as costly a method as planting and compares favorably in expense with broadcasting. The cost per acre of sowing in seed spots will be about as follows:

Cost of half pound of seed (15,000 vital seeds)	$0.75
Cost of sowing seed in seed spots (1,210 spots per acre)	3.50
Total per acre	$4.25

Now, let us consider what are the operations if the area is to be regenerated naturally. The first steps will be very similar except that instead of cutting the area absolutely clean seed trees will be reserved, and when the area is burned over broadcast, precautions are necessary to see that the fire does not burn too fiercely about them.

There are two possible ways of leaving the seed trees—in groups and singly. If the seed trees should be left in groups it would be necessary that the groups be at least an acre in size in order that the trees may

give each other much mutual support. If the groups were 700 feet between centers—the maximum possible for seeding successfully—9 per cent of the logging area would be reserved; this would greatly raise the logging cost, possibly to a prohibitive figure, and yet the groups could not be profitably logged by themselves at a future time with the expensive method of logging necessary in this large timber. The group seed-tree method may be dismissed, therefore, as impracticable *except* in instances where patches of trees are left on ridges, at the head of gulches, and in out-of-the-way corners where it is inconvenient to log them out. In such exceptional instances natural reproduction would be secured from these uncut patches, but such groups would be left not so much intentionally as a practicall silvicultural measure as a requirement of the topography. Ordinarily, therefore, the seed trees will be left singly.

How many and what kind of seed trees should be left? In the first place they must be large trees, that will not be broken down by the falling of their neighbors; they must be potential seed-bearers, and they must be sound and healthy enough to stand up and survive until the regeneration of the area is assured. Judging by the amount of seed produced per tree and by the distance that seed trees can be counted upon to disseminate their seed, and from a study of existing areas of reproduction, it seems safe to say that on the average one good seed tree for each two acres is enough. The amount of seed per tree rather than the distance of dissemination is probably the controlling factor of the frequency of seed trees. A sound seed tree to meet the requirements enumerated above in the stand of average size would have to be about 45 inches in diameter—*i. e.*, with a volume of about 4,000 board feet. It is highly improbable that seed trees left in this way would be usable by the end of the next rotation, and the methods of logging are such that they could not be taken out singly after they had seeded up the area. They, therefore, must be considered a total loss and their whole commercial value be charged up against the cost of reforestation. Such a tree at current stumpage prices, $2 per M feet, would be worth $8, or on an acreage basis the seed trees would represent an investment of $4 per acre. But, and this is a very important consideration, it is not essential or at all advisable that sound 4,000-foot trees, worth $2 per M, should be left for seed. There are in almost every stand a certain number of injured or somewhat defective trees, such as "school-marms," broken or bushy-topped trees, wind-shaken or lightning-cracked trees, and "conky" trees, which have good crowns and are *constitutionally* sound, but of inferior value to the lumberman. Such trees are commonly taken by the logger in western Washington and Oregon because all the timber is

purchased with the land, and the careful timberman desires to take every tree that is his that will yield him any profit at all. Probably if careful account were kept of these semi-defective trees it would be found that many of them do not yield enough merchantable material to pay for their logging. When the logger is paying stumpage, therefore, as he does in sales of National Forest timber, he would prefer to be relieved from handling this class of trees. The stumpage value of this class of seed tree, therefore, cannot be rated as over half that of sound trees, thus reducing the cost of the seed trees from $2 to $1 per M—*i. e.,* from $4 to $2 per acre. Over a large proportion of the Douglas fir land now being logged there are plenty of just such trees which are entirely suitable for seed. On thousands of acres in western Washington and Oregon this class of defective tree is being left by the loggers in their operations because they do not find them profitable to handle, and were a little care given to prevent these trees from being stripped of branches and smashed in the falling of their neighbors or killed when the slash was burned, they would successfully reseed many of the old cuttings. As it is, many fine stands of reproduction on cut-over lands have originated from just such cull trees. The volume of the seed tree is only a small proportion, perhaps 3 per cent, of the volume of the timber that is logged. The cost of logging, therefore, is not appreciably increased, and is safely estimated to be not over $1.50 per acre (3 per cent of the fixed charges of logging an acre). In burning the slashing some pains must be taken to move the debris back from the seed trees and back-fire about them. This will increase the cost of the disposal of the brush perhaps 75 cents per acre over what it would be if the area were to be artificially restocked.

A fair estimate, therefore, of the cost of the single-seed-tree method of securing reproduction in Douglas fir logging is as follows:

Value of seed trees left per acre	$2.00
(Frequently the value will be nil when the trees are actual culls.)	
Increased cost of logging tract because seed trees are left	1.50
Cost of protecting seed trees when slash is burned	.75
Total per acre	$4.25

The estimate made above of the three possible methods give the following comparisons: Planting, $10.25 per acre; seed-spot sowing, $4.25 per acre; single-seed-tree method, $4.25. These are, of course, estimates of average cost, and the actual expense in practice will vary through a wide range depending upon local conditions, but these estimates take account of every factor and are thought to be conservative and com-

parable with each other. They show that the cost of the single-seed-tree method of natural regeneration is practically the same as the cost of artificially seed-spotting the area. One method has no superiority over the other in this particular, therefore, except, as above mentioned, where the reserved trees have no value to the logger, when the financial advantage is decidedly with the natural seed-tree method. But there are to my mind a number of definite advantages to the natural seed-tree method and corresponding disadvantages to the seed-spot method which must weigh with the forester in deciding upon a method either for the Forest Service or for timber-land owners to adopt in their Douglas fir cuttings.

1. The leaving of seed trees would ordinarily require practically no *cash* investment, while the $4.25 necessary to reforest by seed spotting must actually be expended in cash for labor and seed.

2. The fire risk in recently logged-over land is very great for a few years, even after the slash has been burned over once. Suppose a fire gets into an area of five-year-old young growth which has been artificially started and sweeps it clean. The expensive operation of sowing or planting must be repeated at as great if not a greater cost than at first. If seed trees are reserved the young growth may be killed, but the seed trees will be unharmed and they will restock the area without a penny of extra charge.

3. Artificial reforestation is difficult of practical operation. I have said that seed-spot sowing should be successful under favorable conditions, but some of the conditions are impossible of control and may never be favorable on certain sites or may be very unfavorable in certain years. If because of some slight practical obstacle the sowing is delayed perhaps two weeks, the delay brings failure to the operation. A mere enumeration of the obstacles to successful artificial reforestation will suffice to illustrate this point.

(*a*) Years in which seed can be collected profitably do not occur annually, so that sowing in certain years must be done with old seed (which costs more because of its deterioration) or the sowing must be delayed for a year or two (which is bad silviculturally).

(*b*) With a western mountain climate the seasons are very variable, so that large-scale sowing operations are exposed to the seasonal eccentricities of the weather. Some years the dry season follows so closely on the disappearance of the snow that spring sowing would be a total failure on sites where it would be highly successful another year. Similarly in the fall sometimes the sowing season is extremely short because of an early winter, making it difficult to actually carry on the work of artificial reforestation at the all-too-short auspicious season.

(*c*) The labor problem is also serious. The possible sowing (or planting) season in the Cascades either in the fall or spring comes at a time of year when woods work is least attractive, so that it may often be impossible to obtain satisfactory laborers in sufficient numbers at just the time they are needed for large-sized operations.

(*d*) Rodents and birds, the control of which in large-sized field operations has never been demonstrated to be practicable, may prevent a sowing operation from being successful, even when all the other conditions are favorable.

Disadvantages are raised to the single-seed-tree method; it is claimed that the seed trees may blow over; that they may burn up when the slash is burned; that natural reproduction is not sure; that it is slow and may not seed up an area for three, four, or five years. These are all points which must be given consideration, and on certain areas their disadvantages may outweigh the advantages of artificial reforestation. Taking the Douglas fir regions as a whole, however, it is thought that none of these disadvantages is great enough to condemn the method of natural regeneration or hinder its successful application. On most soils single seed trees should not blow over; they can be so protected that they will not be killed when the slash is burned; natural reproduction is reasonably sure, provided the area is not abnormally brushy or otherwise definitely unfavorable for the reception of seed and the seed trees are suitable; natural reproduction may take a year or two years to get started, but since seed years are frequent, and most of the natural reproduction should start the first seed year after the area is burned, it should not be materially slower than artificial sowing.

In stating these reasons for favoring the single-seed-tree method as the method to use in regenerating Douglas fir stands in the Pacific Northwest, I should not be understood as favoring it for all the stands in this region. There are undoubtedly certain classes of Douglas fir timber in which it is better silviculture and more profitable to use artificial reproduction than natural regeneration, but with the above considerations in mind they seem to be the exception rather than the rule. The conditions under which artificial sowing or planting is the better practice may be classed as follows:

1. In very decadent stands, where the Douglas fir is past the seed-bearing age and the forest is given over to hemlock, grand fir, and other secondary species not desired in the next crop, artificial methods must be resorted to in order to secure a second crop of the desired species, Douglas fir. A good many such stands exist in western Washington.

2. In areas where seed trees are very liable to be wind-thrown if left solitary it is wisdom to artificially reforest rather than to run a large risk of losing the seed trees before they have seeded up the area. Such areas are not common, but they do occur on certain kinds of soil and in certain exposed situations.

3. Where *all* the trees in the stand are sound and high grade, and where *every* tree has a high merchantable value, it may be economically more profitable to log every tree and artificially restock the areas than to leave trees of high merchantable value as seed trees. Such a condition as this is rare in the Northwest.

4. Where it is important to secure a cover at once and it is not policy to wait even a year for the natural reproduction, as on a city watershed, or where the competition of brush is feared, or where erosion is to be guarded against, some method of artificial reforestation, preferably planting, must be resorted to.

Whether artificial or natural reproduction should be used in regenerating Douglals fir stands, therefore, must be decided on the ground, according to the conditions in that particular stand and the objects of the management, and it is not safe to say dogmatically that one method or the other is always superior. It is not too much to say, however, that barring the above four classes of exceptional stands, natural regeneration is practicable, reasonably sure of success, and as inexpensive as any method of artificial reforestation in the coastal Douglas fir forests.

A SYSTEM FOR GETTING TOPOGRAPHY IN RECONNAISSANCE WORK IN THE WESTERN CASCADES

BY WALTER H. LEVE

(Contributed)

The material used in this article is based on several years' experience of the author in reconnaissance work and topographic mapping on the Snoqualmie National Forest in western Washington.

The west side of the Cascade Mountains consists of more or less rugged mountain ridges rising from an altitude of a few hundred feet above sealevel to an elevation of 4,000 feet or more. Most of this region is blessed for the greater part of the year with an abundant rainfall and a very moist atmosphere. It is this region of abundant precipitation that is considered herein. The climatic conditions described give rise to a heavy growth of timber, the trees often being of large diameters. A stand of 25,000 feet B. M. to the acre would be considered small, and stands of 100,000 feet or more are not at all uncommon. Except in the thickest stands, the country is also covered with a very dense undergrowth, which is at times higher than a man's head, making an extended outlook quite difficult.

In reconnaissance work there is an opportunity for making a topographic map of much greater detail and accuracy than could otherwise be afforded, and this must be remembered in carrying on the work in order that full advantage may be taken of the opportunity.

Before any reconnaissance work is carried on in a given territory, the man who is to be chief of the party should take a trip through it, visiting points where extended areas of the country may be seen, so that he may make himself thoroughly familiar with the actual conditions that will confront him and plan his work accordingly.

Serious consideration should be given to the selection of the personnel of the party. Men with as much experience as possible should be obtained. The adaptability of the men to the work is very important, and those who are to do the topographical work ought to have a good conception and grasp of this kind of work. The work of a man on the party who has not a good understanding of his work can seriously impair the effectiveness of a number of good men.

Experience has shown that a crew of eight or ten men is more efficient than a larger crew. Where some of the work is not within an economi-

cal walking distance from the main camp, short side camps of two or more men may be established.

If it is possible, the primary control lines should be run out the season before the reconnaissance crew goes into the field; but where this is not possible, the surveying must be well under way when the main crew gets into the field. Some parts of the western Cascades have been covered by the United States public land surveys, and of course where these surveys exist they are used, but in the greater part they do not exist.

The primary control lines or main traverses are usually run up the main stream valleys. These traverses are run along the roads and trails, where there are any, and otherwise up the stream beds. A series of traverses paralleling these should be run along the main ridges where they are timbered. These can often be made quite cheaply by the use of a plane-table with a telescopic alidade and a stadia rod. As the cruising is usually done by means of valuation survey strips, enough short secondary traverses are run out from these main traverses to provide a thorough check on the valuation survey strips. These short traverses are run with a Forest Service standard compass and a chain.. They should be run where the fewest obstacles will be encountered; this may be up a creek bed, or, as is more often the case, up a ridge. Often greater accuracy may be obtained and time saved in running and plotting them by simply making them straight lines carefully chained through the woods. Where the traverses along the main ridges are short and partake of the nature of secondary traverses they may be run with a compass and chain, using the traverse board described later in this article for taking topography. Care should be taken that main topographical features such as peaks, gulches, promontories, etc., be shot in from traverse lines, especially those in the high country which is not cruised.

The cruising is carried on in the following way: On the lower slopes, and where there are good stands of timber, where timber sales are expected within a reasonable length of time, valuation survey strips are run on a 10 per cent basis—that is, strip acre lines, one chain wide, are run ten chains apart. In the upper country, where the stand is merchantable or is expected to become merchantable, but where the cruise is wanted for working plans only, the topography is obtained by well located traverses and the cruise obtained by ocular estimate checked by sample plots. The sample plots may be varied in number according to the importance of the tract. The rough, precipitous, high country which does not bear merchantable stands is not cruised, but some kind of plane-table work is done on it to get the topography.

It was at first thought that a 5 per cent cruise would be sufficient for most of the lower country, and would also be applicable to the upper country, and considerable work has been done on this basis, but it has been found that there are few places where a 5 per cent cruise seems the most practicable. In the first place, owing to the nature of the country, it is rarely possible for the cruiser to judge the character of the topography farther out than five chains from the line he is running. This, then, on a 5 per cent cruise leaves a strip ten chains or more wide on which no topographic data is obtained. The filling in of the topography on this strip is left to the man who works up the field maps. With a 10 per cent cruise the country is almost completely covered from the standpoint of topography, and if the work is done carefully a topographical map is obtained which will not have to be revised for an indefinite period. Further, any area on which a timber sale is expected within a reasonable time will have to be cruised on a 10 per cent basis any way, as a 5 per cent cruise is not sufficient on which to base a sale. There are obvious reasons why this 10 per cent cruise should be made all at once, instead of in two separate 5 per cent cruises. In the upper country, where the cruise is made for working plan purposes only, an ocular estimate by experienced and efficient men, checked occasionally by sample plots, not only offers the data necessary in just as good form, if not better, but is much cheaper than cruising done by the strip acre system on a 5 per cent basis. The latter is worth considering seriously where working plans have to be made for large areas on limited funds.

In laying out strip acre lines in unsurveyed country the main traverse is plotted and a line drawn approximately parallel to this traverse. The strip acre lines are then drawn their proper distance apart at right angles to this line. Where they intersect the traverse line, Forest Service monuments are established for the cruisers to work out from. Care should be taken that these lines are not laid out so as to run directly up side streams and ridges, but that they are laid out so as to cut them somewhat diagonally, thus not only getting more detailed topography but also a more representative cruise.

In cruising on the strip acre lines the cruisers work in pairs. One man, the head cruiser, takes the topography; the other, the second cruiser, tallies the trees and writes the forest description. The head cruiser is responsible for the work of the party and oversees the notes of the second cruiser. The head cruiser carries with him a Forest Service standard compass, a small traverse board fitted to a Jacob's staff, a Locke level, an aneroid barometer, and a tally register. The second cruiser carries a Biltmore stick and a note-book.

The lines are usually paced, the head cruiser doing the pacing, tallying his paces with the tally register. Cruisers who have not had much experience in pacing are required to chain their lines at first. Elevations are obtained with an aneroid barometer, the aneroid being set in camp each morning on starting.

The traverse board and the system of using it are the ideas of Mr. Burt P. Kirkland, the supervisor of the Snoqualmie National Forest. The board is 12 inches square, made of white pine three-fourths of an inch thick. Saw-cuts running with the grain are put in on the lower side one inch apart and three-eighths of an inch deep, to prevent warping. The board is also braced on the bottom with three narrow oak braces mortised into it. Screwed into the center of the bottom is a brass plate, 2½ inches square, into which screws the ball-and-socket staff-head of the Forest Service standard compass. This staff-head fits on the Jacob's staff. The board may be carried by means of a strap slung over the shoulder.

With the use of this board the topography of a given area, say of a square mile or two square miles, is all put on a single map sheet by the cruiser in the field. Thus the necessity of having the compiler copy his topographic data from a large number of individual acre sheets is obviated. The cruiser is given a sheet of convenient size to go on the plane-table, with a definite area laid out on it which he is to work up. A scale of eight inches to the mile has been found to be very satisfactory for this map. It has been the writer's experience that work can be done just as rapidly with this board, if not more so, than with the old system of using individual acre sheets.

On the cruiser's map are located the strip acre lines which he is to cruise, section lines, Forest Service monuments, traverse lines, and any other data which may be of assistance to him. Where the country has been surveyed, such data from the Surveyor General's map as may be of use to him is also put on. In surveyed country the cruiser is usually given a single section to work up at a time. The system admits of considerable elasticity, however, in the size of the area which one cruiser works up. One plan which has been tried is to give two head cruisers areas that overlap. The overlapping territory is left till last, and the man who finishes sooner works it up. This plan is more particularly adapted to unsurveyed country, where the lines are usually of quite uneven length and unexpected obstacles often present themselves.

In mapping an area with this traverse board, the cruiser starts with a strip on the edge of his map and cruises the strips in succession across the map. In this way he is alway running a line next to the one which

he has just previously run and which is fresh in his memory. He has the detailed topography of that line on the map before him and can check it with the one he is running.

The operation of using the traverse board is the same as that of an ordinary plane-table. The compass sets flat on the board and has square edges, one edge being graduated in tenths of an inch, enabling it to be used as an alidade. Objects are shot in with it in the same way as with a plane-table. The cruiser sets the board up at any place along his line where it is necessary to take topography and orients it with reference to the line being cruised. He shows the topography by means of contour lines which have an approximate interval of 25 feet, running them out on his map as far as he has any reasonable certainty of their direction. The Locke level is used to determine the direction of the contour lines where it seems necessary to use it. Aneroid elevations are entered on the map at the beginning and end of each acre and wherever else they are needed. The cruiser puts in the streams, rock outcrops, and any other natural features not shown by the contours. Besides taking the topography on his strip acre lines, he also sketches in the topography along trails and any other lines that he travels on.

By using the compass as an alidade, the cruiser can shoot in any topographical feature that he sees, no matter where it is located. When he comes to a point where he cannot cruise further, he can locate accurately and with little effort the cliffs and other features ahead of him. Often the cruiser comes to more or less open places, such as basins at the heads of streams, where the timber does not warrant cruising or where there is no timber. This plane-table system is well adapted to places like these. If he sees a promontory or other point near his line where a good view of the country can be obtained, he can run a plane-table traverse to it and shoot in all the surrounding topography. Peaks, etc., on the other side of the valley from where he is working, but which could not be located accurately by the cruiser who is working on that side, can also be shot in. This same principle may be reversed, and peaks or other natural features which have been accurately located, say by triangulation, may be used to check the distances paced by the cruiser. In unsurveyed country, where the strip acres are run out from a traverse made along a trail or stream bed, it has been found that it is easier, under this plane-table system, for the cruiser to map in the topography along the traverse than for the surveyor, as the cruiser has the traverse accurately plotted on his map and can put in the topography in the exact proportions in which it occurs.

When the land to be cruised is surveyed, the plane-table sheets for

this work should be made up the winter before the cruising is done and the data from Surveyor General's map and any other required data, such as possibly the data from mining-claim maps, be put on them. For unsurveyed land this can be done also, if the traverses are made the summer before and the man who has charge of making up the sheets has a knowledge of the country.

On his plane-table map the cruiser puts in all data that is of use. Besides the strictly topographic features, he puts in the age class and type boundaries and soil and site quality boundaries exactly as he finds them on the ground. He also puts in all cultural features, such as trails, cabins, mining operations, etc. The kind and condition of trails should be shown.

The cruiser should not fail to get all of the detail that he sees in the field. He should be careful to get the exact direction of the slope, since this has a marked effect on the appearance of the contour lines when they are connected up. His map should also show the degree of roughness of the slope and the amount of rock outcrop. Constant attention should be paid to getting the depth and shape of canyons right, as these are an important factor in the laying out of logging operations. The Locke level should be freely used in these cases, especially where the cruiser has not had a great deal of experience in taking topography. If notes of explanations are needed, the cruiser should not hesitate to put them in on his map.

Before the field season begins the aneroids to be used in a camp should be uniformly and accurately adjusted by a concern that does this work. Then when they are out in the field they should be handled carefully and great care used in reading them. A great deal depends on the accuracy of the aneroid readings. If they are inaccurate and unreliable the topography obtained with their help is almost worthless.

Particular care should be taken to get accurate elevations along traverse and base lines. The most reliable aneroids should be taken out on these lines, and readings taken at various times and the results averaged. With a system of traverses along ridges and stream beds along which accurate elevations are obtained, the compiler is dependent on the strip acre lines rather for the direction of his contour lines only than for both direction and exact elevation. We do not really need to know the exact elevation of all the points on the map; what we want to know is what the country looks like. Now, if we get this relative topography on the strip acre lines, and then have accurate elevations along the important lines, as ridges and stream beds, to tie it to, we are all right. It is more important that we have some of the elevations on

the map accurately determined and not be so careful about the others, than that we have them all determined with only a moderate degree of accuracy. If the important points are not located accurately, the result is a number of small areas on which the topography is fairly well worked up but which do not match with each other. This necessitates considerable warping of topography, especially along the boundaries of the areas, in order to make them match.

Cruisers and others in a reconnaissance party should be on the lookout for names for important natural features that have not already been named. Residents of the locality should be interviewed and all names which are used locally obtained from them.

When the cruiser has finished the field work on his map the aneroid readings are corrected from the daily curve sheets that have been kept in camp. Then it is ready to have the contours connected up and to be gotten into shape for transference to the final map. When finished it should be a complete map of the country which it covers. The contour interval used in finishing these maps is 50 feet. The joining of the contours and completing of the field map should be done by one who is an expert at this particular line. In many cases the cruiser is competent to do this, but sometimes he is not. The man who finishes the field map should not only have had experience in topographical mapping, but he should be possessed of good judgment and a natural sense of topography. Further, he should have been over the ground and should have an understanding of the peculiar characteristics of the country he is working up. Owing to the fact that even after correction the aneroid readings on the strip acre lines cannot be taken as absolute, it is quite easy to make a map in which the topography is badly warped by simply blindly connecting corresponding elevations on adjacent lines. Considerable detail may also be lost in this way. The value of a map may be very seriously impaired by having it worked up by one who has not a thorough understanding of the work. It is evident, also, that an expert can do the work in much less time. Field maps should bear the signatures of all persons who have worked on them.

It should be seen always that the field maps when finished match with adjacent ones. If this is done, and the chief is absolutely certain that he has covered all of the country topographically in some way, it is not necessary to make up the final map in the field. In fact, it is better to use the field season as much as possible for field work and save the compiling of the final map for the time when work in the field is not practicable.

The final map is made up on a scale of four inches to the mile. It is

usually made up in units of townships six miles square, whether the country is covered by the public land surveys or not. The topography is transferred from the field maps to the final map by means of the pantograph, thus preserving all the sharpness of detail that it is possible to get in the field. Under the old system of individual acre sheets this detail was often lost in compiling the final map. However, in order that the details show up sharply, care must be taken that the lines of the field map are followed closely and that no turns or points are slurred over or left out. This same care in following the lines must be used in working up the field maps. The 50-foot contour interval is retained in the final map. It has been found that for ordinary mountainous country on a 4-inch scale map this 50-foot interval is the best. It shows the character and relative steepness of the country quickly and clearly—much more so than 100-foot contours. On less steep country probably a 25-foot interval would be better.

The chief of a party should constantly make notes about the various points that come up. He should discuss these with members of the party and encourage them to record observations and suggest means of betterment. The notes so taken should be filed away for future reference.

Every one connected with a reconnaissance party should bear in mind the purpose of the topographic map. Cruisers, instead of simply going out and drawing in the contours along a certain strip acre line, without any particular regard as to what these contours are supposed to show or to their relation to the contours on other lines, and without paying any attention to the topography beyond the end of the line, should constantly remember that what they are there for is to obtain a topographic map of all of the country—one that shows everything that a person using the country wants to know. It isn't the actual elevation above the sealevel of various points on the map that we care so much about, but what we want to know is what the country looks like—whether it is an even hillside or lies in benches and terraces; how sharp and how deep the gulches are; how high the cliffs are, and so on—our real desire being to find out whether we can get over a certain divide with a pack or not; if we can get up a given side of a valley with a logging railroad, and the hundred other problems that come up in our work in a given country.

Care and accuracy must be insisted upon in reconnaissance work, in order that the work may be of any value or mean anything. Inaccurate and careless work, no matter how intensively applied, is of little value. In planning any operation, the work should be carried only to such an intensity as may maintain accuracy and carefulness. In this way full value may be received from the expenditure of a given amount of money.

FOREST PLANTING IN NORTHERN MICHIGAN

BY WILLIAM B. PIPER

(Contributed)

Forest planting in northern Michigan is in a very early stage of development. The State has been working about ten years and the Forest Service has just begun.

Although northern Michigan, as all know, has had a great reputation for its timber, comparatively little of this timber grew on lands at present held by the State, and even less on lands now held by the Government.

In the early days all Michigan was open to settlement under the homestead, timber, and stone laws. The settlers and timbermen took up and patented the land with the best timber, and stole much of the timber from the lands that were not worth patenting. The best lands for agriculture have been held or sold by the original patentees, while the poorer lands that were patented have reverted to the State on account of non-payment of taxes. Only the poorest and sandiest lands were left in the hands of the Government. Part of these now form the Michigan and Marquette forests. The result is that the State has the medium lands to protect and reforest and the Government has the poorest lands.

In the Michigan forest, in the spring of 1910, 25,000 Norway pine, wild stock from Minnesota, were planted. Those put in the ground in early April, just as soon as the snow melted, are doing far better than those that were planted during the latter part of April and in early May.

That same spring white-pine seed were sown, but the soil was too dry to allow germination.

In the Michigan forest, in the winter of 1910-1911 and the spring of 1911, a large amount of Norway-pine seed was sown. One area was sown in December, 1910, and disked in April, 1911. Four areas were sown in March and April, 1911, and disked in April, 1911. The seed came from the Michigan and Minnesota National Forests. One area was sown with jack-pine seed from the Minnesota National Forest.

To see whether rodents ate the seed, experiments were made on four other areas.

The Norway-pine seed sown on them was treated:

1. With coal tar.
2. With red lead.
3. With pine tar.

On a fourth area, wheat treated with strychnine and saccharine was sown about two weeks before the Norway-pine seed. Since the germination on the treated areas and on the untreated areas was approximately the same, the poisoning seemed to be ineffectual.

Some of the seed sown on the broad-casted areas sprouted, but the hot sun the latter part of June and the early part of July scorched the seedlings.

Several areas were sown in April with Norway-pine seed in "seed-spots" spaced 6 feet by 6 feet apart. A little space was cleared of sod by means of a "Hazel" hoe, and eight or ten Norway-pine seed sown in a spot. They were put in with the hoe, much as corn would be sown, at the rate of an acre per day per man. Nearly 80 or 90 per cent of these spots showed fine, thrifty little pine seedlings in May and early June, and promised well; but, as was the case with the broadcast seed, the hot sun of the last of June and early July scorched them so that today hardly a seedling can be found in the seed-spots. So many seed came up in the spring that there is not much chance of any large per cent of the seed having failed to germinate.

In the early part of May, 1911, 28,000 two and three-year-old white-pine seedlings from the Michigan Agricultural College were planted. The white pine had "heated" badly in transit, and showed a low per cent of vitality. White-pine seed needs a soil less sandy than that of the "plains," and more shade than can be had there. A thousand Norway-pine transplants, also from the Michigan Agricultural College, were planted near the white pine. These were rather large to handle, were planted late and at a dry time, and show poor results.

A thousand Scotch pine and two thousand Western yellow pine from the Detroit and Mackinac Nurseries at East Tawas were also planted early in May. The weather was too hot or the soil conditions not right for the Western yellow pine, and that has not been a success. The Scotch pine, however, though it looked brown in the summer, seems to have been revived by the heavy fall rains, and promises good results. This capacity for reviving is especially encouraging for the future planting of Scotch pine here. The fact that it is an exotic species is not in its favor.

In the autumn of 1911, 500 white-pine 3-1s and 500 Western yellow-

pine seedlings, three years old, from the Detroit and Mackinac Railroad Nurseries at East Tawas, and 2,000 Norway-pine seedlings, three to six years old, from Minnesota, were planted. It is too early after planting to say how these are going to develop, but with all the fall rains that occurred shortly after the planting the result should be good.

In the spring of 1911, in an old garden at Oscoda, some Norway-pine seed was sown to see what it would do under the best of conditions. Early in May, before the snow was all gone, several beds, 4 feet by 8 feet, were carefully prepared and Norway-pine seed from Minnesota sown in them. A mulch of clean straw was put over the beds and watered thoroughly. In early June, as soon as the seed had started to germinate, the straw was removed. Lath screens, giving half shade, were put on the beds exposed to the direct rays of the sun, but left off a bed that was shaded partially by an oak tree and a shed. The frequent rains of early June and the cloudy weather that came then enabled the seedlings to flourish well at first, just as did the seedlings that came up in the "seed-spots" sown on the "plains." As soon, however, as the rains stopped and the sun came out hot, in the latter part of June and early July, the beds required frequent watering (in the evening) to keep the seedlings alive. At times a fine sprinkler was left playing water on the beds all night. The sandy soil here absorbs a great deal of water, and irrigation is out of the question. A long-continued gentle spraying is required to make any noticeable effect one inch or even half an inch below the surface of the ground.

The Norway-pine seedling is more susceptible to "damping off" than that of any of the other pines. Even in this dry, sandy soil this disease is very evident, and on account of the sandy nature of the soil is the harder to fight. At one time the seedlings would be suffering from lack of water, and at almost the next moment signs of "damping off" were evident. The result was that a large loss of seedlings occurred in some of the beds. Another year it is planned to fight the disease with commercial sulphuric acid and with formalin.

At the end of the growing season the seedlings at Oscoda that were in the bed partially shaded by an oak tree and a shed, were far thriftier and had a much better color than those protected by shade screens (the latter were removed altogether early in September). The seedlings in the beds which had been protected by screens had a yellow tinge, and were not so large as the ones in the bed receiving natural shade. A little protection from the sun is advisable during the last part of June, July, and August, and the Forest Service plans to use jack-pine limbs to bring this about. The seedlings in the above beds were transplanted

in the autumn of 1911 to the new nursery site on Silver Creek, some eight or ten miles northwest of East Tawas. In taking them up, a remarkable root development was found on the seedlings, the roots varying from 4 to 12 inches long, averaging about 6 inches. The height of the seedlings above ground was normal—about 2 inches. The soil had been worked up thoroughly, and had been enriched with a fine, well decomposed manure, with the result that it was very light, and therefore the roots had a great chance to penetrate downward. To prevent such a long root growth and to get a better lateral root system on the seedlings, a foundation of clay has been put in three of the 4-foot by 12-foot beds started on the Michigan forest in the autumn of 1911. Hauling this clay costs about $1.25 a bed. The Detroit and Mackinac Nurseries adopted this scheme in some of the beds at their nurseries at East Tawas several years ago, with good results.

It is very important to sow the seed in the beds in the spring as soon as the ground can be worked, in order to get germination of the seed. The seed was put in as early as possible at Oscoda, even before the snow was all gone; the soil is so sandy there it can be worked then. Norway-pine seed sown later at the Detroit and Mackinac Nurseries at East Tawas did not germinate at all, even though it was watered with a hose. With Norway-pine seed costing $3.15 a pound, planting nursery-grown stock is cheaper than direct seeding.

Example: If three pounds of Norway-pine seed are sown to the acre, this makes an initial cost of $9.45. Add to this the cost of disking at 50 cents an acre and labor of sowing at 50 cents, we have $10.45.

The cost of planting is something as follows:

Cost of seedlings, $3 per M; 1,210 to acre, planted 6 feet by 6 feet	$3.65
Cost of transportation, 50 cents per M, or 61 cents per acre.....	.61
Cost of planting, $3.50 per M; planting 6 feet by 6 feet; $4.24 per acre..	4.24
Total..	$8.50

The cost of Norway-pine seedlings from Minnesota is about $4 per M at Minnesota, which would bring the price up a little over a dollar an acre more. It would not make the cost of this surer method, however, compare badly with the cost of the broadcasting and disking method.

One great drawback in getting seedlings from Minnesota is that the spring in Minnesota is later than the one in Michigan. One of the great points in Michigan is to plant the seedlings in the spring just as soon as the snow goes off, and the best way to put this into effect is to raise seedlings in a local nursery; then they are right on hand ready for use.

The State Forester of Michigan has not found raising seedlings, even in nursery beds, all smooth sailing. The State nurseries cover about six acres of sandy land at the headquarters of the State's reserves at Higgins Lake. Here are raised white, Norway, Scotch, Western yellow, and lodgepole-pine seedlings, as well as black, white, and blue spruce and a few minor species. The seed-beds of Norway pine planted in the spring of 1911 looked exceptionally well in most instances in the summer of 1911. The seeds were sown in drills and came up in good shape. "Damping off" one day and drying out the next has caused the death of a few seedlings, but as a rule the beds had a good stand in them in the summer of 1911. It was noticed in one bed, the last of August, that some of the Norway-pine seedlings had died down and were wilting. Rubbing the hand over them toppled the dried plants over, and it was seen that the wilted seedlings had been cut off evenly just beneath the ground by some unknown cause, as if with a pair of shears. This was in only one bed.

Lath screens giving half shade were used in the summer of 1911 over most of the beds. The seedlings in these beds had a deep, rich green in August. The seedlings in the few beds where screens were not used had not quite so dark a color, but looked hardy. Some protection from the sun throughout the latter part of June, all of July and August, and the first part of September is advisable in this country, as the results show. It will therefore be seen that the seedlings even under the best of conditions have a very severe struggle, so it is not to be wondered at that the areas where direct sowing was done by the Forest Service in the winter of 1910-1911 and the spring of 1911 do not show a good stand of seedlings.

A ten-acre plantation set out by the State of Michigan in the spring of 1904, with two-year-old Scotch-pine stock from the Waukegan, Ill., nurseries, planting about a thousand seedlings per acre, is doing beautifully. This is the oldest plantation the State has. The stock is all well above the brush now and makes splendid growth each year.

Another tract of sixty acres, planted in the spring of 1906 to two-year-old Scotch-pine stock believed to have been raised at the Higgins Lake Nursery, and planted about a thousand per acre, is coming on fairly well, in spite of the fact that the trees were planted in heavier brush. The death rate here, however, was considerably more than in the 1904 tract, where about 90 per cent lived.

The State has, in addition, approximately ten acres scattered about in very small plots, planted in the spring of 1905, 1906, 1907, and 1908 by the former Forestry Commission.

The white-pine seedlings planted by the State in the spring of 1911 on cut-over lands near the State Nursery are struggling through the heavy underbrush around them. A good percentage was still alive at the time the writer was there, but it was too early to make an accurate count. They were planted by the "slit system," a specially devised tool planned by State Forester Schaaf being used for making the slits. The tool consists of a flat piece of iron half an inch thick by three inches wide, sharpened at one end. A step is riveted to the upper side to use in pressing it into the ground with the foot, and a stiff piece of iron pipe is attached to the upper end to use as a handle. A spade is too fragile an article to use in making the slits in the soil, as was discovered several years ago by the State, and again proved to be the case on the Michigan forest in the spring of 1911. Instead of tramping the earth about the plants with the heel at Higgins Lake, they made one slit in which the plant is put, and then two slits alongside parallel to the first one, pressing the earth toward the plant and thus closing up the dirt arount it. This leaves a little hole a few inches from the plant, but not close enough to it to allow it to dry out. It also packs the dirt firmly around the plant, which is of particular importance in this dry, sandy soil.

The "slit system" has the advantage of being over 50 per cent faster than using a mattock, but has a great disadvantage—the grass and weeds cannot be cleared from around the plant so easily as they can be when the mattock is used. To my mind the mattock is the more satisfactory tool to use if the seedlings are planted with care and enough pains are taken to press the dirt compactly around them.

No planting on the Marquette forest has been done yet, but some broadcast seeding of Norway pine and jack pine and some "seed-spot" sowing of Norway pine was tried on that forest in the spring of 1911. As on the Michigan forest, however, the sun was too hot for the tender seedlings. In the latter part of June and early part of July the sun scorched and killed them. Upon the Michigan forest the Norway-pine seed sown in the "seed-spots" showed a remarkable per cent of germination in May.

With our present knowledge, therefore, the plan is to grow Scotch and Norway-pine seedlings in seed-beds, and to buy Scotch and Norway-pine seedlings for planting out on the "plains." Scotch-pine seed can be secured cheaply from abroad and grown in seed-beds at a comparatively low cost, and the Norway pine wild stock from three to six years old from Minnesota promises well. Planting should be done at six or seven dollars an acre, and this is far surer and cheaper than broad-

casting seed costing over three dollars a pound or planting it in "seed-spots."

From the work so far done it appears possible to draw four fairly definite conclusions:

(1) Planting home-grown nursery stock or thrifty wild stock which can be definitely secured before snow leaves promises the most satisfactory results and is cheaper than broadcasting or seed-spots.

(2) Broadcasting is a waste of time and money on the dry, hot, sandy lands.

(3) White pine promises little success on the driest sandy lands.

(4) Scotch pine promises most and Norway pine next.

INTERRELATION BETWEEN BRUSH AND TREE GROWTH OF THE CRATER NATIONAL FOREST, OREGON

BY HAROLD D. FOSTER

(Contributed)

SCOPE OF THE STUDY

The data which forms the basis of this study is the result of notes and observations taken in connection with other work and is necessarily somewhat general in its scope and restricted in its range. It is believed, however, that the regions studied may be considered as typical of conditions on the Crater National Forest, exclusive of the watersheds of Ashland Creek and Applegate River. These watersheds, which are in the Siskiyou Mountains, present some features which in some respects vary from conditions as found in the main part of the Crater National Forest, which comprises the southern extremity of the Cascade Range, as is noted below. This study is concerned only with the portion of the Crater National Forest within the Cascade Mountains. In the discussion mention will be made of the alpine, transition, and slope types of forest. These terms correspond to the alpine, upper slope, and lower slope types of my annual silvical report of February 18, 1911.

DEFINITION OF BRUSH

There is some confliction evident in the local use of the term "brush" which necessitates a definition of terminology at the outset to avoid confusion. The terms "brush" and "chaparral" are commonly used indiscriminately in local parlance to denote areas covered wholly or in part by brush growth, whether or not there is some scattering timber in the area. Such areas are more commonly called "brush," though "chaparral" is also occasionally heard to denote the same condition. "Chaparral" is usually understood locally to denote a particular species of shrub rather than an ecological classification, but is applied to several species without any phylogenetic or taxonomic relation.

The definitions as given by Mr. Fred G. Plummer in Bulletin 85 of the Forest Service, entitled "Chaparral," will be accepted for the purpose of this study. On page 8 Mr. Plummer thus defines "chaparral" and "brushland":

"*Chaparral.*—An area whose permanent and mature crop is a mixed forest of stunted trees, resulting from certain climatic conditions which produce sclerophyllous or hard-leaved dwarfs. In the United States it is found in heath scrub, maqui, shrub steppe, etc., which are peculiar to sclerophyllous woodland regions in other countries."

"*Brushland.*—An area whose crop is low trees or shrubs having no commercial value. The occurrence of brush creates a distinct type, but all land supporting brush does not belong to the type. When brush occurs under a cover of large trees in the form of undergrowth, underbrush, or thicket, the classification is either timberland or woodland. Brush may temporarily form an exclusive cover, owing to the removal of large trees from the area, but such a temporary cover of brush does not remove the land from the type to which it previously belonged. When this temporary cover includes some of the species which are found in true chaparral, its form may be termed mock chaparral."

Accepting these definitions, there is no true chaparral on the Crater National Forest unless perhaps on some of the hot, dry slopes of the Applegate watershed, where a xerophytic type is encountered which appears to be original and permanent.

Considering exclusively that portion of the Crater National Forest within the Cascade Mountains, there is no true chaparral. Brush occurs very generally throughout the forest, occasionally forming an exclusive cover, but as shown below there is evidence that this condition is temporary in character and consequently not to be considered as an ecological type, but rather as a transitional phase in the history of a forest type.

COMPOSITION OF BRUSH

The following is a partial list of shrubby plants or small trees which enter in greater or less proportion in the composition of brush areas and heavy undergrowth in forest:

Adenostoma fasciculatum
Arctostaphylos
Castanopsis chrysophylla
Ceanothus
Amelanchier
Arbutus menziesii
Berberis aquifolium
Cercocarpus parvifolius
Cornus
Corylus californica
Gaultheria shallon
Pachystima mysinites
Prunus
Quercus douglasii
Rhamnus purshiana
Rhus diversoloba
Salix
Spirea
Vaccinium

Of these only the first four are important as forming an exclusive cover, or occurring in forest in sufficient density to affect seriously the

silvical conditions of the forest Of these four *Ceanothus,* called locally by the names of "snowbrush" or "slick-leaf," is the most important as having a wider geographical range and forming a large part of the brush on areas denuded or thinned by fire. Species of this genus are particularly difficult to identify, especially inasmuch as they hibridize freely, but it is thought that *C. velutinus* and *C. sanguineus* are the principal species found in brushland.

DISTRIBUTION OF BRUSH

Several factors influence the distribution of brush aside from the presence or absence of forest or the density of the forest in which it may occur as underbrush. In the vicinity of Four Mile Lake, though the forest (of the alpine type) is rather open, there is relatively little underbrush, while to the east, on the watershed of Four Mile Creek, which is the outlet of the lake, *Ceanothus* is very thick in the transition and slope types of forest.

The same causes which have contributed to the differentiation of forest types may be assigned to the presence or absence of brush in these two typical regions, which lie but a few miles distant from each other. In other words, the altitude, exposure, the long cold winters and short growing period, which adapt the region of Four Mile Lake to the alpine rather than the transition or slope type, conspire also to unfit the locality for the production or perpetuation of brush. In fact one of the characteristics of the alpine type of forest is the absence of brush areas or of any form of undergrowth save such low-growing, hardy plants as *Vaccinium.* It may, therefore, be said that brush, save as a thin ground cover, does not occur in the alpine type. For this reason any brush-covered areas on the upper slopes or ridges may be safely classified in the transition type, since undoubtedly the forest which originally occupied the site was of this type rather than the alpine type.

The several species which enter into the composition of brushlands have somewhat diverse climatic and site requirements which further restrict the geographical range of each. Thus *Arctostaphylos* constitutes the majority of the brush growth on Cat Hill on a thin-soiled west exposure on the west slope of the mountains, while on the east side of the divide this genus occurs only scatteringly as single individuals in brush areas or as undergrowth in forest and does not reach elevations above 5,500 feet. *Ceanothus,* on the other hand, occurs on all slopes on both the east and west sides of the divide, in the slope and transition types, to the upper limit of the transition type.

Castanopsis chrysophylla occurs as a secondary species in brushlands on both sides of the divide, on thin, dry soils, though it is more frequently encountered on west slopes on the west side of the summit. Under favorable conditions, in dense, cool forest, with deep, damp soil, *Castanopsis* assumes a treelike form, with a diameter of some 8 or 12 inches.

Adenostoma fasciculatum is unimportant in the Cascades, occurring in dry soil in the vicinity of Klamath Lake, as a sparse undergrowth in the open yellow-pine forest; but on the Applegate River watershed, in the Siskiyou Mountains, it constitutes a true chaparral on hot, dry mountain slopes.

It will thus be seen that forest types are characterized not only by their tree species, but equally so by the brush growth occurring in each; while, as is equally true of tree species, some species may have a wide distribution in various aspects and in different types, others are more restricted in situation by reason of their several requirements.

CLASSIFICATION OF BRUSH

Bearing in mind that on the Crater National Forest there is no true brushland in the sense as defined by Mr. Plummer, but that the presence of brush is an evanescent stage in the life history of the forest, we may classify brushy areas, for convenience of study and description, into three types, as follows:

1. Areas on which brush growth is the only cover or in which tree growth is present only as scattered saplings and seedlings.
2. Areas which are occupied by a cover of brush with an occasional large tree.
3. Forested areas with underbrush dense and tall enough seriously to impede reproduction.

Of the first class, Cat Hill may be taken as typical. On the area chosen for Experiment No. 4 practically every aspect is presented, owing to numerous gulches. The general slope, however, is westerly. Before the "Cat Hill fire" of 1910 the soil was occupied by a very heavy growth of mountain manzanita, chinquapin, snowbrush, mountain ash, cherry, aspen, and willow. About one-half of the brush growth was manzanita, the balance being chinquapin, and the other species occurring in small scattered patches. On the northerly slopes and in the gullies the brush was mostly of chinquapin, which here grew 7 or 8 feet tall and very thick. On the southerly aspects and on the summits the brush was largely of manzanita, on the top, where the soil is thin, being only about 4 feet high and not thick.

A hasty examination of the area would lead to the conclusion that there was no arborescent reproduction. In fact the site was chosen as an experimental planting area after a reconnaissance of the region, largely because of this apparent total lack of trees. There were found to be, however, half a dozen trees of lodgepole pine and white fir tall enough to appear above the brush, while there are no seed-bearing trees of any species within a quarter of a mile or so of the experiment plot except in the canyon north of the area. Moreover, a careful examination at the time of seeding revealed the fact that scattered over the area were young trees ranging up to 3 feet in height in surprising numbers in view of the fact of the great distance of seed trees. Nowhere, however, were the seedlings abundant. The species represented in the order of their abundance were white fir, lodgepole pine, Douglas fir, mountain hemlock, sugar pine, yellow pine, and Engelmann spruce. The yellow pine and spruce were, however, very scarce, only a few individuals of each species being found.

An old resident furnishes the information that 30 years ago Cat Hill was bare of either brush or timber. Very few charred logs were found, but enough to indicate that the slope was once covered with a forest which must have been destroyed by fire many years ago. Fire again spread over the slope in 1910, killing the brush to the roots. This was, however, only a temporary setback, since the brush has vigorously coppiced from the roots. The scattering reproduction, however, was annihilated. The winter following the fire extensive seeding operations were conducted on Cat Hill, but the result has been far from satisfactory.

Numerous brush areas similar to Cat Hill occur in various parts of the Cascade Mountains within the Crater National Forest, but there are few as large as the Cat Hill burn.

Of the second class, areas which are occupied by a cover of brush with an occasional large tree, a slope east of Lake of the Woods is typical. It is a high west slope lying above a transition forest, in which Douglas fir, white fir, and noble fir are the predominant species, and in which yellow pine is entirely absent. It consists of a large brush-covered area with scattering trees of yellow pine and white fir—trees of the lower-slope type. The yellow pine forms the major portion of the scattering stand, and the trees of this species are very tall and cylindrical. What little reproduction there is consists of white fir and yellow pine. The brush is the ubiquitous *Ceanothus*, with small clumps of *Salix*. The trees, though very scattering—two to five per acre—are sufficiently large to constitute a stand of 4,000 feet per acre.

Of Class 3 the forest of Four Mile Creek watershed is typical. Here

is a forest of white fir, yellow pine, and Douglas fir of 8,000 to 30,000 feet per acre. The cover is open to broken; the brush, which is almost entirely of *Ceanothus*, is very heavy; the reproduction of tree species is scanty, occurring only in spots devoid of brush. This is the characteristic forest of the slope type on the east side of the Cascade Mountains. Everywhere are evidences of fire appearing as charred fallen trees, scarred butts of living trees, and disease and deformation in the trees.

Some of the forests are free or almost free of brush. This condition is common in the alpine type for reasons stated above. In dense stands of lodgepole pine the cover is evidently too dense and the trees stand so close together that there is no room for undergrowth. In the very dense forests near Fish Lake, which average 48,000 feet per acre, there is an understory of western yew with some little dogwood. This, however, is rather in the nature of an underwood than underbrush, since the species forming the understory are treelike in nature. This is practically the only undergrowth in forests of this description. The cover is very dense, not admitting sufficient light for underbrush. The soil is damp and the dead and fallen trees are soggy and moss-covered even in midsummer. There is no evidence of fire having ever been in this forest.

CAUSES OF THE PRESENCE OF BRUSH

The density of the forest cover seems to be a principal factor in the presence or absence of brush. Other factors, such as humidity and depth of soil, exposure, and aspect, play an important part in determining the species that constitute the brush. Some species also are less tolerant of shade than others, so that a forest that would support an underbrush of huckleberry may be too dense for *Ceanothus*, though the altitude, soil, and climate might not be adverse to the latter species. Western yew appears to thrive in the densest shade, provided it has sufficient soil moisture; but yew does not constitute an element in the typical underbrush or brushy areas of the Crater National Forest. Moreover, as shown below, fire appears to extend the range of brush areas, while yew is very easily killed by fire. Yew is found only in forest too dense to support brush.

The indications are that direct sunshine is not so essential to brush as diffused light. In canyons and on north slopes where there is little direct sunshine there is often considerable brush, providing there is little or no shading from overhead trees. But on flats or southern exposures, where without forest the sunlight would be intense, there is often no brush if the forest cover is heavy, while on the other hand it will persist under a

fairly dense canopy so long as a modicum of overhead sunlight filters through the foliage to supplement the diffused light that enters from the side in a moderately dense stand. Forest cover, then, seems to be directly responsible for the amount of underbrush present. It is, however, a difficult matter to state just how much overhead shading the brush will endure, since it is a difficult matter to measure the amount of shade. Perhaps the best method is to express it in terms of percentage of sky visible to an observer standing in the forest. Thus when no cover is present, as in a stand of seedlings or open brush area, the shade would be 0 per cent, the percentage increasing with the increase in the cover. In similar manner the amount of brush may be measured in terms of percentage of bare ground visible to the eye looking down from above the brush, on the assumption that the brush does not exceed in height the level of the eye. In general terms, then, the amount of brush may be said to be in inverse proportion to the amount of overhead shade cast by the forest cover. This rule is, however, modified by such local conditions as altitude, soil, climate, and aspect. More specifically, in localities otherwise favorable to brush, there is practically no underbrush when the forest cover exceeds 80 per cent.

So far as I have observed, there is nowhere any *Ceanothus*, which is by far the most prevalent species in brush areas and as underbrush, where there is no evidence of forest fires. I have noticed many instances in the alpine type where the forest has been injured or even destroyed by fire, and outside as well as inside the alpine type, where the type has been modified to a pure lodgepole pine stand through the agency of fire, in which there is little brush of any kind and no *Ceanothus*. In other words, forest fires are not always followed by the extension of this species. The great Cat Hill burn came up largely to manzanita and chinquapin instead of *Ceanothus*. But I have not found a region in which this genus is abundant which failed to show evident signs of the action of forest fires. Areas burned over in all degrees of severity and each followed by the appearance of *Ceanothus* are to be found on the east side of the Cascade Mountains. On the east slope of Black Butte near Lake of the Woods is a patch of *Ceanothus* brush of some 600 acres, which by the presence of infrequent charred fallen trees gives evidence that the original forest was totally destroyed so long ago that the charred stubs have long since fallen and almost entirely decayed.

A burn of more recent date is illustrated in Photograph No. 85652. This is near Four Mile Lake. Here the forest was totally destroyed, but the charred stubs are still standing among the *Ceanothus* and manzanita brush which succeeded the forest. This was originally a transition forest of white fir, Douglas fir, and noble fir.

In the burn on the westerly slope east of Lake of the Woods, which is mentioned above, the fact that the few yellow-pine trees still standing are fire-scarred leads to the conclusion that they are remnants of the original forest. That they started from seed scattered subsequently to the date of the burn is not at all likely, for they are evidently several centuries old, and the nearest yellow-pine forest is many miles below this area, and the burn is bounded above by an alpine type and below by a transition type in neither of which is any yellow pine. That the trees sprang from seed from the original forest is just as improbable, for a fire hot enough to destroy even the veteran seed trees would certainly destroy all seeds and cones lying on the ground.

In the slope-type forest on Four Mile Creek watershed the density of the cover has been broken and the stand thinned, though not destroyed, by fire. The remaining trees are everywhere fire-scarred, while stag-headedness, cat-face, and dry rot have further decreased the value of the stand. *Ceanothus* brush, which requires a certain amount of light, has crept in and is now very thick.

Adjoining the Four Mile Creek watershed and stretching southward toward Lake of the Woods is a forest of the same type and approximately the same proportion of species. Evidences of fire are fewer here, however, the forest denser, and the amount of brush is very much less. As the evidences of fire increase, the density decreases and the amount of *Ceanothus* brush increases until the typical condition of the Four Mile Creek watershed is reached. It is apparent that the prime cause of this condition was forest fire, which thinned the stand and opened the canopy, making it possible for the brush to survive under the partial shade.

This supposition is further strengthened by the observation of a burn near Lake of the Woods. In this instance an area of about 10 acres was burned over rather recently. Charred down trees and stubs are in evidence and the bases of the remaining trees fire-scarred. The area has the same characteristics as the surrounding forest except that it has been thinned by this recent fire, the cover is more open, and the brush, of *Ceanothus,* is heavy, though almost lacking in the surrounding forest.

BRUSH IN RELATION TO FOREST REPRODUCTION

The number of forest seedlings in brush areas seems to be dependent upon the size of the brush patch and the age of the burn. The Cat Hill burn is very extensive, and yet it occurred so many years ago that forest seedlings had gained a foothold from natural seeding, though growing very slowly under the dense shade of the brush. Other much smaller

brush-covered burns have been observed, in which no forest seedlings were discernible. The reason has been determined in a number of cases to be the more recent date of the burn, and it is probable that this is true of all such cases. It has been determined that at least eight years is required to seed up a clear-cut area by natural means in the yellow-pine forest, and it is probable that a much longer time is required in any very extensive burns.

In brush of the second class, where a few seed trees remain after the fire, natural reproduction is more satisfactory, and still more so in forest thinned but not destroyed by fire. But even in such forest natural reproduction is often very unsatisfactory. This point will be considered in the discussion of the advantages and disadvantages of brush.

BRUSH ON LOGGED LANDS

But little opportunity is presented for the study of the interrelation of brush and tree growth on logged-over lands. Timber sales on the Crater National Forest are all of relatively recent date. On such cut-over areas, which have invariably been conducted on the selection system, brush was originally present in more or less amount on some and totally lacking on others. The amount of brush has not been appreciably increased on any of these areas, though in a few years' time it may be found to have increased on some. It is probable that brush requires several years to become established after logging, as does natural forest reproduction.

On an area near Odessa, in the open yellow-pine forest, which was cut over 23 years ago, reproduction has come in abundantly with no brush. The reason for the absence of brush in this case doubtless is due to the absence of brush in the open yellow-pine forest which surrounds the cut-over area. The locality is naturally not adapted for brush and is separated from any brushy areas which could seed it after the forest stand had been thinned.

On the right bank of Recreation Creek is another old cutting which was logged at about the same time. Here the *Ceanothus* brush is heavy, reproduction very scant, and evidences of fire apparent. The brush, however, appears to be no heavier and the tree seedlings scarcely less numerous than in the surrounding virgin forest, which has been thinned and injured by recurrent fires.

The data available is too scant to form a definite conclusion, though there is no evidence to lead to the belief that underbrush is increased by logging, as it obviously is by thinnings caused by fire.

On the other hand, the amount of underbrush is often very appreciably lessened by logging operations. This is accomplished principally by the construction of roads in places previously occupied by brush, by the tearing action of skidding and hauling logs, whether by wagon or donkey engine, and also to some slight extent by brush burning. These agencies are, of course, equally destructive to any forest reproduction that may be present in the brush.

ADVANTAGES AND DISADVANTAGES OF BRUSH

On slopes that otherwise would be devoid of vegetation brush areas are of great importance as serving to conserve the water supply by retarding the run-off and evaporation and keeping the soil loose. After total destruction of a slope forest by fire, many years are necessary for natural reforestation, but the more rapid establishment of brush tides over the period when otherwise the slope would be barren and preserves the soil in fit condition for reforestation. It also serves to furnish a partial shade to the forest seedlings, which may be introduced through natural means or artificially, protecting them in early youth from the severity of the direct rays of the sun and from the drying action of hot winds or the cold blasts of winter storms until they are old enough and strong enough to withstand adverse climatic conditions. As the trees push their crowns above the brush they in turn shade it, and if the new stand is sufficiently dense it will eventually destroy or greatly reduce the underbrush.

There is, however, more danger that brush may hinder rather than aid reproduction. It is often so dense as either to preclude it or retard its growth. It occasionally whips the young trees, as it is swayed in storms, so as to destroy the tree buds.

Brush in forest makes travel difficult off from the usual traveled trails, while brush-covered burns are practically impassable even to the traveler on foot. This is not only inconvenient, but often of great concern in patroling the forest or in quickly traveling to a forest fire. In forests choked with underbrush or in large brush-covered areas it is necessary to have a network of trails in order to make the country accessible, while in the open yellow-pine forest free from brush it is possible to travel in almost any direction even if trails are not numerous. Trails are not so essential in dense, moist forest, owing to the lesser fire hazard, although travel may be equally difficult, while forests in which the underbrush is thick are usually particularly susceptible to fire. Such forests are rather open, the soil is dry, and fire, which originally brought them to this condition, is more than ever likely to recur.

The brush in itself may or may not increase the fire risk. Fire spreads very slowly through green *Ceanothus* brush, and a surface fire originating in open forest is often checked when it reaches a patch of green *Ceanothus*. Other species, such as manzanita, whose leaves and wood contain a natural oil, may greatly aid in the spread of a forest fire. The Cat Hill fire of 1910 originated in the manzanita brush and spread with incredible velocity to the timber.

Great difficulty is experienced in trenching for backfiring in a brush-covered area or in a forest with heavy underbrush. The closely interlaced roots and the tangle of shoots offer a serious obstacle to the manipulation of tools, while a ground fire smoulders for a long time among the roots.

METHODS OF DECREASING OR DESTROYING BRUSH

Although brush as a ground cover, especially on deforested areas and as a partial shade for seedlings, has undoubted utility; in some cases it is a serious hindrance in the protection or extension of the forest. Even on deforested areas its value as a protective cover is not greater than that of a commercial forest which might much better occupy the site. It therefore is desirable to devise some method to control it, and the object that the forester has in mind will often determine or at least restrict the method to be followed.

Several natural means of reducing or destroying brush are at the disposal of the forester. Fire rarely if ever destroys a brush cover or heavy underbrush. Some species coppice vigorously from the roots, particularly greasewood and *Ceanothus*, while almost inevitably, even if the coppicing power is destroyed, the ground is restocked from seed blown in from surrounding brushy areas. The rapidity with which the new cover is established depends on several factors, such as the severity of the fire, the proportion of species in the original stand which will coppice, the position, distance, and proportion of species in neighboring brush stands. Even if not destroyed by the first fire, the vitality of the brush is reduced and subsequent fires may entirely eradicate it.

This method of destroying brush can never be used artificially on this forest. A fire hot enough to kill underbrush would greatly injure the forest, while in a non-forested area the difficulty of controlling a brush fire would be almost insuperable. It would be next to impossible, too, to start a fire in green brush unless in such inflammable species as manzanita. In any event, firing would have no silvicultural value unless repeated often enough to destroy roots as well as shoots, unless the first fire were promptly followed by artificial reforestation.

The fire which burned the brush on Cat Hill in 1910 retarded its growth, lessened its vitality, and let in more light by killing it down to the roots. It thus resulted in an improved seed bed for the seeding, which was done the following fall and winter. If the seeding had been successful the seedlings would undoubtedly have profited by this burning, since they would have been able to get a start in height growth before the coppice shoots had choked them out, while at the same time receiving sufficient protective shade from the killed and leafless twigs of the burned brush. But the reproduction naturally on the site was totally killed, so that in all probability the fire accomplished as much damage as benefit.

Another natural agency in reducing or destroying brush is insect infestation. During the summer of 1910 an attack of some unknown insect of the order *Lepidoptera* was observed. The larvæ were black, naked caterpillars, which literally covered the *Ceanothus* brush on a broad hillside. A few weeks later the brush was observed as entirely defoliated and the insects had pupated. A short time afterward the imagos had emerged in the form of small brown moths, while the new leaves were beginning to appear on the brush. It was very evident that one such attack had failed to kill the brush. It is believed that repeated defoliations would so devitalize the plants as to kill them, though it is doubtful if such a defoliation occurs in successive years or sufficiently often to destroy the brush.

One of the slowest, but perhaps the surest, natural agencies in the destruction of brush is the formation of a forest cover, and this is a method that is used artificially. On such brush areas as the Cat Hill burn, where forest tree seedlings were present naturally, the seedlings would in time if sufficiently numerous have compassed the destruction of the brush by forming a dense shade over it, and thus killing it by shutting off the light.

Several methods of destroying brush by artificial means are apparent, though each has certain features that render it impracticable or of restricted utility. It is, however, usually neither necessary nor desirable to totally destroy the brush, at least until after a satisfactory forest stand is established, when the shade cast by the forest cover may be depended upon to reduce the brush sufficiently to do away with its adverse features. It sometimes is necessary, however, to reduce the density of the brush before reforestation, artificial or natural, can succeed.

The method of firing has been touched upon and its impracticability discussed. It is sometimes possible, however, as after the Cat Hill fire of 1910, to take advantage of a brush fire by following it promptly by planting or sowing.

Another quick and obvious method is to cut down or thin the brush with ax, machete, brush hook, or pruning shears, and to pile and burn the brush. The brush, however, would coppice as it does after a fire, so that the clearing or thinning would be but temporary unless repeated annually. This, however, would be too costly to be practicable, as would also grubbing out the roots, unless the cover were thin, in which case the method of planting or sowing and allowing the growing trees to shade out the brush would be sufficient.

It might be possible to herd a band of goats on brush land till the animals had defoliated the bushes. This method would have the further advantage of preparing the soil as a receptive seed bed for artificial forest seeding by the harrowing action of the goats' hoofs. It seems doubtful, however, if even goats would browse the leaves of manzanita or *Ceanothus* without a preparatory half-starving process. This method, as in the others mentioned above, would have but temporary effect unless often repeated, but if followed promptly by seeding or planting of forest trees might be successful. This method would be best adapted to a forest of thin cover, in which the brush is too dense to allow sufficient natural regeneration. When used in such cases, it should be done immediately before the dissemination of the seed from the parent trees in a year of abundant seed production.

This method of inducing natural reproduction has been successfully accomplished by Dr. C. A. Schenck on the Biltmore Forest in North Carolina. Dr. Schenck fenced an experimental area, in which he confined some half-starved cattle immediately before seeding time. The cattle browsed and trampled down the brush and harrowed the soil with their hoofs. They were then excluded and a very gratifying seeding of yellow poplar resulted, where before the reproduction of this valuable species was very unsatisfactory. Cattle or even sheep would not accomplish this result in the unpalatable manzanita and *Ceanothus* thickets of the Crater National Forest, but if opportunity presents it would be desirable to experiment with goats, for there seems to be no apparent reason why such an experiment should not be attended with satisfactory results.

The area of the Utter and Burns timber sale on Anna Creek is a forest of overmature yellow pine, with a lesser proportion of white fir. The underbrush of *Ceanothus* is tall and usually rather thick. Some difficulty in logging was anticipated for this reason. The logs, however, were hauled to the sawmill by high wheels, which easily rode down the brush, while the ends of the logs dragging on the ground tore up the brush and pulverized the soil. Enough seed trees were left standing for natural reseeding and to furnish a partial shade to the young trees, so that the

brush was not needed to protect the seedlings from the sun. Conditions for an ideal seed bed have resulted and the area will be watched with interest, since it is hoped that natural seeding will be greatly stimulated.

Five methods of artificially reducing or destroying the brush on old brush-covered burns or in forest have been discussed—firing, grubbing, slashing, grazing, and logging. The first of these has been dismissed as entirely impracticable on the Crater National Forest. The others may have some utility on restricted areas, principally for the purpose of thinning or reducing the brush rather than totally destroying it, but the results of most are but ephemeral. Even such methods as appear more thorough and permanent, such as grubbing and the secondary results of logging operations, should be followed promptly by reforestation, either natural or artificial, in order that the new cover may get a start before it is choked out by the rapid growth of root coppice. Even if the brush is totally destroyed artificially or naturally the area should be reforested immediately before the ground has dried out or been reseeded naturally to brush from adjacent brush areas.

In some areas the brush is not too dense seriously to interfere with the growth of the tree seedlings. Reforestation may then be accomplished artificially or through natural agencies without previous preparation. Where too dense, one of the methods outlined above may be resorted to, though it is rarely if ever necessary or desirable to destroy the brush totally. Whether the brush is too dense for the successful germination and development of seedlings can only be determined by careful observation of the site under consideration and by comparison with other localities. No instructions can be prescribed for all cases, since other factors, such as the tolerance of the tree species to be grown, the amount of seed to be sown, or number of plants to be set out, or the number, vigor, and age of seed trees, have an important though varying effect on the success of the attempted reforestation. After the young trees have pushed above the brush, they will more and more shade it until it perishes from want of direct sunlight or of sufficient intensity of diffused light.

Here, then, is a sixth method of ridding the forest of brush. It and logging are the only ones that have been practiced on the Crater National Forest, and even these have been but ulterior results of operations that had more or less different objects.

SITKA SPRUCE OF ALASKA

BY BRUCE E. HOFFMAN

(Contributed)

Sitka spruce (*Picea sitchensis*) is well known to be the most valuable commercial timber tree in Alaska. Its soft, straight-grained wood and the general large sizes attained by individuals of the species make it an excellent saw timber. Approximately 90 per cent of the annual cut by Alaskan sawmills is Sitka spruce. Other native species form a larger percentage of the forest, yet their defects, smaller size, and inferior wood qualities place them low in the scale of competition for construction or box purposes.

Thus I have briefly stated the importance of the species, and it is needless to mention any reasons why special attention should be given to the spruce. There are certain natural influences encouraging its growth, while on the other hand nature has furnished the forest with one species (Western hemlock) that proves to be the only obstacle to a future forest having the spruce as its predominating species. It is my intention to give in detail its local habits and a rough outline of management that may be a step toward altering the forest type and encouraging the regeneration of spruce.

LOCAL RANGE AND OCCURRENCE

Sitka spruce occurs throughout the forests of southeastern Alaska. It confines itself chiefly to low elevations along valleys, streams, and the lower portions of mountain slopes where it associates with Western hemlock. Only on very small areas—say from one to two or three acres—does Sitka spruce occur in pure stands. The upper limit of merchantable spruce is about 1,200 feet; above that it grows more or less small and scrubby. At about 2,400-feet elevation there are but very few, if any, spruce trees; at any rate, they are very short and scrubby. These elevations limiting different types of the species vary, and generally become lower in more northerly sections of the forest.

The forest might be divided into three types in general, as follows:

1. *The Lower-slope and Bottom-land Type.*

This type includes elevations up to 1,200 feet and the low land along streams or along salt water, called bottom land for convenience. In

general, Western hemlock predominates and spruce comes second in the mixture. Practically the same conditions exist on the bottom land as on the slope, except that the hemlock and spruce are invariably the only species present on the former. This type contains practically all of the merchantable spruce saw timber. Toward the upper limit, or sometimes as low as 300 feet, yellow cypress makes its appearance; in fact, the bulk of it, as far as present information goes, is found below an elevation of 1,200 feet. Western red cedar also appears in largest quantities from about 200 feet above sealevel to 1,200 feet.

There are also, in many instances, muskegs upon which a low, scrubby form of lodgepole pine grows.

2. *The Upper-slope Type* (1,200 to 2,400 feet elevation).

Spruce occurs in small quantities in this type, and seldom reaches a merchantable size. At the upper limit it is nearly absent. Western hemlock makes a healthy growth in the lower part of the type, but is gradually replaced by mountain hemlock (*Tsuga mertensiana*). The two latter species predominate. Western red cedar is very scarce generally in the lower portion of type, and only a few scrubby trees reach the upper limits.

3. *Timber-line Type* (above 2,400 feet elevation).

In this type the scrubby mountain hemlock predominates, and in fact it is generally the only species present, there being some Western hemlock and lodgepole pine.

STAND

The bulk of Sitka spruce in the lower-slope type is mostly in small tracts of about 10 to 100 acres, and averages from 10 to 90 thousand feet, board measure, per acre. The estimate of timber on the Tongass National Forest is placed by approximation at 67 billion feet, board measure. The approximate total stand of Sitka spruce, considering this species to constitute 15 per cent of the stand, would be, in round numbers, 10 billion feet, board measure.

HABIT

Seedlings of Sitka spruce are delicate and make a very slow growth for the first two or three years, and then assume a vigorous height growth and overtake their associates. The stem tapers rapidly, especially in trees growing in a more or less open forest. The trunks of

those receiving little or no lateral shade are very branchy, and, when cut, produce a very knotty grade of lumber. Large trees are often swollen or buttressed at the base. This swollen condition exists in about 50 per cent of old trees, and is in most cases due to the fact that the seedling made its growth on top of a log or boulder. In other instances the swollen portion is not so large in girth, but extends further up the bole. Generally this form indicates a defective base.

Sitka spruce is a comparatively long-lived species, the mature trees ranging in age from 250 to 350 years, while certain individuals reach an age of 500 years. It is a persistent grower throughout life. Several sound trees, between 400 and 500 years old, noted by the writer, appear to have made their most rapid diameter growth between the ages of 350 and 400 years. The ordinary dimensions reached by the species vary from 30 inches diameter at breast height and 90 feet in height to 60 inches diameter at breast height and 125 feet in height. Many trees attain a breast height diameter of 70 to 80 inches and a height of 150 feet. These dimensions do not include any swell bases. The maximum height attained in this region is about 175 feet. Exceptional cases have been reported from reliable sources of trees containing 25,000 board feet.

The root system is shallow and spreading. On the Rocky Mountain slopes, where there is scarcely any loose soil, the roots lie close to the surface and often above for a considerable portion of their length, yet the tree grows vigorously and develops a perfect form. On the deeper soils at the foot of slopes and along rivers the roots lie more beneath the surface, but not below a shallow depth. No reference has been made to the wood or any botanical characteristics for the reason that the descriptions given in Sudworth's "Trees of the Pacific Slope" and in other publications apply accurately to the species throughout this forest.

TOLERANCE

Sitka spruce is fairly tolerant throughout life. Seedlings make an exceptionally slow growth under dense shade, especially where Western hemlock seeds heavily at the same time. Where abundance of sunlight is present for the first two or three years after seeding takes place and the slow growth completed, the young trees endure shade fairly well and compete successfully with other species in height growth. Later in life they stand shade well, and invariably outclass all associating species in height growth.

A fully-stocked stand is desirable in order that a long, clean bole may be obtained. The Western hemlock, which predominates so generally

with the spruce, is without a doubt very beneficial in furnishing shade to hasten the clearing of branches of the more valuable timber tree. The hemlock grows more slowly in later life, is very tolerant, and regenerates freely under the dense shade and on the deep humus or moss that is so prevalent under dense forests in Alaska. The clearing of branches in closed stands occurs between the ages of 50 and 70 years.

REGENERATION—SOIL AND CLIMATIC INFLUENCES

Although Sitka spruce is not very exacting in its soil requirements, its best reproduction and growth requires a mineral soil. The two principal factors in the quality of the locality governing the reproduction are soil and sunlight. This species may be classed, in this portion of Alaska at least, as the one demanding very little rich fertile soil for its growth. Wherever landslides have occurred and the mineral soil exposed, one of the first tree species to spring up is Oregon alder, and as soon as it has grown to a height of several feet the spruce has formed a dense understory. The alder growth is more or less open and does not materially hinder the valuable undergrowth. On areas logged by steam, where the surface is torn up and gravelly soil exposed, spruce seedlings spring up in abundance and outstrip any of the local associating species in growth. Spruce seed will germinate and grow on decayed logs. A small percentage of young seedlings continues to grow successfully from this source, and develop into the large, swell-buttressed trees that make up a considerable portion of the stand, while a majority of them never grow beyond the seedling stage. Along the rough, rocky slopes, seedlings of this species spring out of crevices or from small ledges where a small quantity of soil has been formed from disintegration. Many large-sized trees develop in such places.

All of the above conditions are influenced by the quantity of light present, of course. Wherever the soil is unfavorable for germination and there is plenty of direct sunlight, many seedlings develop successfully. Where both soil and light conditions are favorable the spruce predominates. Burned areas make up but a small per cent of the forest area, and they generally occur where the forest consists principally of Western red cedar, lodgepole pine, or Western hemlock. There is usually a deep moss soil covering, or, in many instances, the muskeg type exists, which is seldom burned to expose any mineral soil. Where there are any live spruce seed trees on burned areas whose soil has burned to expose the mineral constituents, a dense reproduction may be assured. The chief climatic factor favoring the regeneration of this species is the

abundance of rainfall and of fog. The average annual rainfall for southeastern Alaska is about 125 inches, and this is so generally distributed that there is little opportunity for the comparison of growth under wet and dry conditions. The excess of moisture undoubtedly is the chief factor in stimulating growth on poor soils. Sitka spruce seems to receive a benefit in some way from ocean fogs. It has been noticed in at least two cases, where there is a very heavy and healthy stand in the bottoms of small valleys, that fog settles more frequently than in the surrounding territory. The exceptionally high quality of the timber and heavy stand I believe tends to show that the increased humidity is the most beneficial factor in the climate. It was noted in each instance that protection was afforded against cold north winds and the maximum amount of sunlight could reach the south slopes for a greater part of the year.

The temperature in southeastern Alaska is rather moderate, varying from 6 decrees below zero in the vicinity of Ketchikan to a considerably lower degree about Juneau and Skagway. The lowest temperature at Ketchikan for years was in the months of December, 1910, and January and February, 1911, when the mercury fell to 9 degrees below zero. The highest average temperature is about 90 degrees Fahrenheit. Killing frosts cease in the spring about April 15 and begin about September 15. It is questionable whether or not an occasional severe cold winter affects the tree in its dormant condition, but it is worthy of note that this last summer, 1911, which followed an exceedingly cold and long winter, was characterized by the entire absence of spruce seed. Not even a single cone was seen by several members of the Forest Service here.

Although out of place under this heading, it seems necessary to mention that the spruce does well on all slopes and exposures, while those facing the south receive more direct sunlight, and consequently afford the best growing site.

SEED

Sitka spruce is a prolific seeder, extra heavy seed years occurring at intervals of three or four years. Speaking from general observations, the seed has a moderately high germination per cent and good vitality. This last season was, for some reason, an off year, as there was absolutely no spruce seed borne. At least no cones were seen by officers of the Forest Service. The seed crop of other tree species was very scanty, which leads me to believe that the long, severe winter preceding has a tendency to make trees utilize all of their stored-up foods for growing purposes. The gathering of spruce seed so far has been limited partially to timber-sale areas, where cutting is in progress. This proves to be unsatisfactory,

because trees are in dense stand more or less, and bear only small quantities of seed. Fairly good success has been made by climbing trees along the beach and picking the cones. In case of difficulty in gathering seed, it would seem advisable to let seed collectors cut old defective trees for the seed. The seed from such sources might not be best, but the loss in cutting the trees would be small, and large quantities of seed could be obtained.

The following data were taken from results of the seed collecting done in 1910:

Total quantity of cones gathered	152 bu.
Yield of uncleaned seed per bushel of cones	2.3 lb.
Yield of cleaned seed per bushel of cones	.65 "
Total quantity of uncleaned seed shipped from Ketchikan	351 lbs.
Average price paid for collecting cones per bushel	$0.51
Average cost of transporting cones per bushel—field to Ketchikan	.10
Average cost, gathering and transportation, per pound of uncleaned seed	.265
Rent, cost of beater, and other necessary material, per pound of uncleaned seed	.108
Total cost per pound of uncleaned seed	.375
Cost of cleaned seed per pound	2.06

DISEASES AND DEFECTS

There are two serious defects present in Sitka spruce. These occur generally in mature and overmature trees. The commonly called heart rot is found in the upper portion of the trunk and follows the central part, or axis, of the tree sometimes for half of its length, thus making that part worthless for saw timber. This defect seems to be the result of a fungus entering through wounds, such as broken limbs. Trees having heart rot can generally be detected by the presence of a sort of black knot, or "conk," but in many cases trees appearing to be perfectly sound from the outside are worthless when cut.

The second defect is a rot at the base of the tree. This occurs mostly in large and old-aged trees having swell buttresses. It originates in the center of the bole and works radially and upward. Sometimes the rot extends only five or six feet above the ground, while in other cases a 16-foot log has to be thrown away. Specimens of each of these rots will be collected this season and sent to the Bureau of Plant Industry for a determination of the fungi.

There are several other defects decreasing the quantity and quality of the timber. Wind-shake is present in many large, old trees standing in

exposed places. This is often accompanied by a spiral grain, in which case the entire tree is worthless for saw timber. Loose knots occur frequently in lumber sawed from trees which grow in a more or less open forest. Where the lumber is sawed thin for box shooks, a great deal of waste results. Pitch seams cause some loss in lumber cut from old trees, but not to any great extent.

USES

Sitka spruce has two important uses in Alaska, namely, for box shooks used in the salmon canning industry and for building material. It is soft, holds nails well, and is strong. As a box wood it is very satisfactory, and in building purposes the main fault seems to be with its shrinking. Its fibers tend to shrink excessively in a lateral direction and somewhat longitudinally. Perfect kiln-drying seems to prevent this, however, and its use is very extensive throughout this region. As an interior finishing wood it is used extensively. It has a very pretty grain and takes a stain and paint well. It is used somewhat for piling, but "teredos" attack it within a short time after it is placed under water and riddle piles in one or two years. Certain cases are known where they were rendered useless in six months after being driven. Western hemlock has proven to be a superior wood in resisting attacks of the borer, and is being used almost exclusively for that purpose.

LUMBERING

Since Sitka spruce is the principal species used for saw timber in southeastern Alaska, special features of the lumber industry and their influence upon economic and forest conditions deserve some consideration. Until very recently logging has been done by hand along the shores. The class of timber secured, therefore, has been more or less defective, and there has been much trouble over the scale and prices paid for raw material. The mills are very crude. The circular saws and out-of-date, rickety machinery, combined with unskilled labor, butcher many thousand board feet each year. The general tendency among business men in Alaska is to "grab all you can and get out;" so, with this in view, the mill men, under the many adverse conditions, have held log prices very low. They have been up against three adversities, namely, the competition of Puget Sound fir, defective timber secured along the shore, and a small output from their mills. In addition to lowering the prices paid for logs, so that they could operate successfully under these conditions, they have cut prices down additionally or swindled the logger

in the scale, so that he could hardly exist. Since the Forest Service scale has removed any unfair deals of this kind and the demand for steam-logged timber has increased, many donkey outfits have been working. The log prices have been increased from $3.50 and $4.00 up to $4.50 and $5.00, plus the stumpage. The ordinary steam logging outfit consists generally of one donkey mounted on a float which may be towed to any bay or point where work is to be done. About 2,000 feet of cable are carried and a distance of about 900 feet from the beach covered. In one instance the contractor has two donkeys, a roader and a yarder, equipped with sufficient cable to reach back from the shore about 2,500 feet. In this case pole roads are used. Good bodies of timber must be had in order to allow the logger a profit, and he cannot go to any heavier expense in purchasing equipment that will reach back a mile or more from water without receiving higher prices for his logs. The bodies of available timber within 1,000 and 2,000 feet of the shore line are already scarce, so that the next step in the development of the industry must be an improvement in the class of mills and more careful utilization. This will bring about higher log prices and encourage the cutting of a larger quantity of the overmature spruce and perhaps some of the Western hemlock. There is no reason whatever why up-to-date band mills having a daily output of from 50,000 to 100,000 board feet cannot be operated successfully in this region.

The canneries of southeastern Alaska packed approximately three million cases in the summer of 1911, and in this connection used approximately 27,000,000 board feet of lumber for cases alone. About 40 per cent of this lumber was supplied by sawmills located on the Tongass National Forest and the remainder by lumber companies in the States. Many of the canneries endeavored to secure their shooks from local mills, but were turned down on account of the mill companies' inability to supply. It is very evident that the establishment of better mills and improvement of present mill methods would improve forest conditions and benefit the Forest Service silviculturally as follows:

1. Timber-sale regulations could be carried out more carefully and on better silvicultural principles by (*a*) less waste and (*b*) by favoring the most valuable species (Sitka spruce), and alter the type by encouraging the growth of spruce and cleaning out some of the hemlock.

2. Greater returns to the Service through increased stumpage rates and increased annual cut.

3. More rapid utilization of the overmature timber through increased annual cut.

The following table shows the average percentage of each grade sawed from Sitka spruce:

	Per cent.
Clear	15
No. 1 Common	20
No. 2 Common	15
Box	20
Dimension	20
Cull	5

The average amount of waste in local mills is about one-half cord for every thousand board feet cut.

The average retail prices are as follows:

Rough lumber, mill run, per thousand	$15.00
½-sized, mill run, per thousand	16.00
Ship-lap, mill run, per thousand	17.50
Select (finish), per thousand	20.00
Finish, clear, per thousand	30.00

The above grades are those recognized by the Ketchikan mill.

Approximately 40 per cent of their output is manufactured into box shooks, each box requiring nine board feet of lumber. The price for shooks in 1911 was 10 cents at the yard.

The average cost of logging by steam is as follows:

Felling and bucking	$0.75 per thousand.
Lopping tops	.02
Yarding to booming place	$1.50 to 2.00
Booming	.15 to .25
Total	$2.42 to 3.02

The higher cost is about the average, including hauls up to 2,500 feet from the beach. The lower cost was reported by a logger having a very accessible tract, where the longest haul did not exceed 600 feet.

The following statement is one submitted by the Ketchikan Mill Company:

Cost of Lumber Manufacture per Thousand Feet, Board Measure.

Stumpage	$1.00
Manufacturing license	.10
Log cost in raft at place of cutting	5.00
Towing	.75
Boom cost (bucking and placing on deck)	.20
Sawing	1.875
Trimming	.75
Edging	.375
Yard cost	1.00
Planer, cost on finished stuff	1.50
Loading and selling	1.00
Fuel and oil cost	.50
Upkeep	.50
Total	$14.55

MANAGEMENT

All but a very small quantity of the valuable spruce timber in southeastern Alaska is included in the Tongass National Forest. There are several private timber claims containing a stand sufficiently large to supply the local mills probably one year. These claims will no doubt remain untouched for many years, as I believe the timber is comparatively young and higher values are desired.

Considering the foregoing facts, it is evident that this forest will be relied upon for the supply of saw timber, and in the near future the supply of pulp wood. In view of this, it is necessary for the Service to formulate a plan of management as rapidly as possible that will contain provisions for a sustained annual yield. The first step to be taken along this line must be to alter the type on the better-growing sites and encourage the Sitka spruce. In order that the spruce may be favored and its regeneration encouraged to reach the maximum, several conditions must be brought about:

First. There must be sufficient reconnaissance carried out for the location of the tracts containing spruce, either merchantable or in an early stage of life.

The extensive form of reconnaissance will satisfactorily furnish such information. This reconnaissance would show on a large scale map the approximate location of merchantable or dense stands of spruce and the distribution of those types in which this species might be made to predominate.

Following the extensive reconnaissance, the valleys or water-sheds containing merchantable bodies of spruce, or spruce and hemlock mixed, can be accurately cruised and mapped. Merchantable stands of Western hemlock may be included, because they will be the source of supply for prospective pulp mills.

Second. Improvement of present milling methods and an increased annual cut. This would bring about higher log values and enable loggers to go further inland for their timber. The excess of overmature timber would be more rapidly removed, more hemlock used for saw timber, and in general better silvicultural methods practiced in cutting.

Third. The introduction of the paper pulp industry. Large quantities of hemlock will be utilized by pulp mills. Clear cutting in this case, and reserving spruce seed trees where they are not liable to be uprooted will be very favorable for regeneration of the more valuable species.

One of the serious drawbacks at present is the absence of data on hand showing the location of available bodies of merchantable timber. The loggers are at present cleaning up every small tract along the shore and constantly inquire for information relative to logging chances. If the Service had the necessary data on hand it might be possible to refuse the sale of some of the younger growing stands and limit cutting to those more decadent in character. The competition of fir lumber undoubtedly has as strong an influence as the lack of reconnaissance data on the sale of timber. Log prices are so low in comparison with the demand that only compact bodies of timber can be cut.

The first step in the systematic management of Sitka spruce following the development of the above outlined conditions should be to limit cutting of saw timber to the more decadent stands. Marking may be done where there is a healthy young growth or middle-age stand in connection with the large mature and overmature trees, providing that the soil conditions and exposure will not place the remaining trees subject to windthrow. Favorable conditions for marking will be few, because the soil is generally so shallow and heavy winds occur so frequently. On watersheds where the timber is to be cut for pulp purposes hemlock will be the principal species, and if possible spruce seed trees should be reserved and the plan of clear cutting carried out as far as possible. Clear cutting is by all means the best system for securing a reproduction of the spruce and discouraging the hemlock. On the ordinary tract included in timber sales where the area is small, spruce will reseed sufficiently to produce a heavy reproduction except after poor seed years, in which case artificial means should be employed. This could be accomplished by

broadcast sowing or sowing in seed spots, the latter being the most applicable on account of the ground being covered in patches with lopped tops. Seed spots could be easily prepared where the soil is torn up in logging operations. Ordinarily spruce seed is carried by wind a distance equal to about twice the height of the tree. Where large areas are cut over for saw timber, seed trees should be reserved where practicable. In case it is inadvisable to leave any seed trees and the area is too wide to permit its being reseeded by trees standing along the margin, artificial means should be relied upon. Tracts to be cut over for pulp wood will be excellent locations for the growth of spruce. Western hemlock will be the predominating species present in such sales, and a clean-cutting system should be adopted. There are in nearly every hemlock forest scattering bunches or individuals of spruce, and where the soil conditions and exposure are favorable seed trees of this species should be reserved. In most cases it will be out of the question to leave any seed trees, and the seeding will have to be done artificially. This should be done promptly at the end of each season, so that the seedlings will have the minimum resistance to growth. Devil's club and huckleberry bushes come in freely on cleared areas, and in combination with hemlock seedlings would make a serious obstacle to young plants of the valuable tree species.

Small bodies of saw timber should be reserved from cutting for pulp purposes. The best rotation for Sitka spruce cannot be predicted with any accuracy until measurements of growth have been made or regulated cutting methods tried out. The average virgin growth in closed stands is about 22 inches in 100 years. Nearly all trees cut for saw timber are overmature and vary from 300 to 450 years old. The average merchantable saw timber age is estimated to be from 100 to 150 years.

The problem of seed gathering is one that needs some attention. Certain quantities should be gathered every good seed year and tests made to determine the per cent of germination, vitality, and other qualities of seed collected from different localities. The volume table on the following page was compiled from scale measurements made by E. C. Erickson and is fairly accurate for estimating the Sitka spruce.

ALASKA VOLUME TABLE FOR SITKA SPRUCE

This table is based on the measurement of 500 trees, and shows the actual merchantable contents of sound trees in board feet as determined by actual scale with Scribner Decimal C Rule. Volumes evened off on curves. The trees upon which this table is based were principally from closed stands with from the minimum to the average taper and of the average merchantable length:

D. B. H.	Volume, board feet.	Average merchantable length, feet.	Average taper in inches, 32-foot log.	Average top diameter.
20...........	560	80	4	13–15
21...........	630	"	"	" "
22...........	720	"	"	" "
23...........	810	"	"	" "
24...........	900	"	"	" "
25...........	1,010	"	"	" "
26...........	1,130	94	5	" "
27...........	1,250	"	"	" "
28...........	1,370	"	"	" "
29...........	1,520	"	"	" "
30...........	1,660	"	"	" "
31...........	1,800	"	"	" "
32...........	1,970	"	"	" "
33...........	2,150	110	"	" "
34...........	2,340	"	"	" "
35...........	2,520	"	6	" "
36...........	2,710	"	"	" "
37...........	2,900	"	"	" "
38...........	3,080	"	"	15–17
39...........	3,240	"	"	" "
40...........	3,400	"	7–8	" "
41...........	3,560	"	"	" "
42...........	3,730	"	"	17–20
43...........	3,890	"	"	" "
44...........	4,050	"	"	" "
45...........	4,150	"	"	" "
46...........	4,250	"	"	" "
47...........	4,350	"	"	" "
48...........	4,440	"	"	" "
49...........	4,530	"	"	" "
50...........	4,660	"	"	" "
51...........	4,810	"	"	" "
52...........	5,020	"	"	" "
53...........	5,280	"	"	" "
54...........	5,630	"	"	" "
55...........	5,820	"	"	" "
56...........	5,960	"	"	" "
57...........	6,070	"	"	" "
58...........	6,170	"	"	" "
59...........	6,260	"	"	" "
60...........	6,330	"	"	" "

NOTE.—Volumes in this table for trees above 40 inches D. B. H. are only approximate, as it was impossible to find many trees for measurement.

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WATER-POWER ON THE NATIONAL FORESTS

BY JAMES B. ADAMS

Delivered before the Society May 23, 1912

WATER-POWER RESOURCES OF THE NATIONAL FORESTS.

The conservation of water as well as of wood was contemplated by Congress when it enacted legislation providing for the creation of National Forests. The law establishing National Forests provides that unappropriated public lands, wholly or in part covered by timber or undergrowth, may be reserved and set aside as National Forests for the purpose of securing favorable conditions of water-flow and to furnish a continuous supply of timber for the use of citizens of the United States; it also contemplates the utilization of their natural resources and any beneficial use not inconsistent with such purposes. (Acts of March 3, 1891, 26 Stat., 1095; June 4, 1897, 30 Stat., 11.) The Appalachian Forest act, only recently approved, authorizes the purchase from private owners of timbered lands in the Eastern States on the headwaters of navigable stream for the purpose of regulating stream-flow and conserving forests. (Act March 1, 1911, 36 Stat., 962.)

NATIONAL FORESTS PROTECT THE HEADWATERS OF ALL IMPORTANT WESTERN STREAMS

Included within the National Forests are practically all the mountain ranges of the West, and in these ranges are the headwaters of all the important streams from which power may be developed. Since the

National Forests are created to protect the forest cover from destruction or depletion, they constitute an important factor in the water-power development of the West. With practically no exceptions, all the power developments of consequence on streams west of the Mississippi River either utilize National Forest land or use water from streams which head in National Forests.

A list of the principal power developments of the West will clearly illustrate the situation. The Pacific Gas and Electric Company of California, with its development of approximately 120,000 horsepower, utilizes streams rising in the Plumas, Tahoe, and the Eldorado National Forests. The Great Western Power Company, with a present development of 60,000 horsepower and a prospective development of 350,000 horsepower, develops its power upon streams within the Lassen and Plumas National Forests. The Pacific Light and Power and the Southern California Edison Companies, with an aggregate present development of approximately 150,000 horsepower and a prospective development of about 250,000 horsepower, will utilize streams within the Sierra, Sequoia, and Kern National Forests. Similarly the developments that supply Denver utilize streams within the National Forests in the Rocky Mountains in Colorado. The developments which supply Seattle, Tacoma, and Portland utilize streams rising in the National Forests in the Cascade Mountains of Washington and Oregon. The developments of the United Missouri River Power Company, which supplies practically all the power generated in Montana, utilizes streams rising in the National Forests of western Montana. The headwaters of all of these streams are dependent upon the protection afforded by the forest cover in the National Forests.

NATIONAL FORESTS CONTAIN A LARGE PART OF THE WATER-POWER SITES

Of the water-power estimated to be possible of development from the low flow of all the streams in the United States, 70 per cent is found in the eleven States west of Kansas. Of the total in these States, 64 per cent, or about 12,000,000 horsepower, is estimated to be within the National Forests. Of the remaining 36 per cent, or 7,000,000 horsepower, probably not less than nine-tenths is protected by the National Forests.

AMOUNT OF POWER NOW DEVELOPED AND APPLIED FOR ON NATIONAL FORESTS

On March 1, 1912, there were in effect 165 permits for water-power plants in whole or in part on National Forest land, covering a total

development of 1,380,000 horsepower. Of this amount 240,000 horsepower is in plants already constructed and in operation. The permits which have been issued cover power development ranging from less than 10 horsepower to more than 300,000 horsepower. Forty per cent of the 165 permits are for developments of less than 1,000 horsepower.

RELATION OF WATER-POWER USE TO OTHER USES

To the Use of Water

There is an absolute need for water in every-day life, and it is an essential factor in the industrial welfare of the country. Its uses may be broadly grouped in the order of their present relative importance under four heads: Domestic, irrigation, navigation, and power.

The necessity for water for domestic purposes—that is, for drinking, culinary, and sanitary uses—is, of course, appreciated by every one, although perhaps not so much by those who live in localities of abundant rainfall as by the inhabitants of regions having long periods of drought, where the storing of water is necessary in order that a supply may be available at all seasons of the year. The securing of an adequate quantity of water is one of the greatest problems many of our large cities have to meet. Frequently it is necessary to go a great distance in order to provide a suitable supply. As an illustration, there may be cited the case of the city of Los Angeles, California, which is now engaged in building an aqueduct about 200 miles in length, through a desert and across a mountain chain at a cost of many millions of dollars, so that it may secure a sufficient supply of pure water to meet the present and prospective needs of its citizens. This great aqueduct brings water from streams within a National Forest.

The use of water for irrigation is extensively practiced in the semi-arid sections of the Western States, and thereby large tracts of lands otherwise practically valueless are put under cultivation and made to support thousands of people. The streams from which water is secured for this purpose have their sources in the mountain regions.

The larger streams of the United States were at one time extensively used for navigation, and are to a great extent still used for that purpose. Their use for navigation can be greatly enlarged if proper steps are taken to equalize stream-flow by preventing floods and increasing the flow at the natural low-water period.

From the earliest times water has been used in the development of power, but until recent years it was necessary to use the power in the immediate locality where it was developed. Through the wonderful

improvement which has taken place within the last decade in the methods of generating and transmitting electrical energy, it is now possible to use the power obtained from water at a great distance from the locality at which the power is actually found. There are within the National Forests several hydro-electric power plants, which generate electric energy and transmit it 100 to 200 miles. Water-power is frequently found in one State and the energy obtained therefrom actually used in another.

Water-power is the physical effect of the weight of falling water. It follows, therefore, that in order to obtain power there must not only be water, but it must fall. Sometimes the water and fall are found together in nature, as at Niagara, where power can be developed within a limited area. Sometimes there is a large volume of water with but slight fall, as in the Mississippi River and other large streams, where power can be developed through the construction of a dam which makes an artificial fall. At other places there is a rapid but not precipitous fall, where power can be developed by diverting the water from the stream and conducting it by conduit over adjacent lands to a point whence it is allowed to fall a considerable distance through a pipe to a generating plant on the stream below. Plants are now in operation which utilize an artificial fall of nearly 2,000 feet obtained in this way. By the use of a small quantity of water a tremendous amount of power can be obtained through a fall of this height. The latter is the kind of water-power development usually made within National Forests, because of the numerous mountain streams within their boundaries.

The use of a stream for the development of power does not preclude its use for domestic purposes or for navigation. On the contrary, whenever the flow of a stream is regulated by storage, as is usually the case when it is put to its highest power development, its value for both of the other uses is increased. The use for irrigation, however, is generally inconsistent with the use for power, because large quantities of water are wanted for irrigation during the seasons of the year when crops are growing, whereas, in the development of power, stored water is needed at the season of natural low flow. These seasons do not occur together. The period of natural low flow is usually during the fall and winter, which, of course, is not the time when water would be wanted for irrigation. The assertion, therefore, that water stored for power may also be put to an irrigation use is generally only partially correct.

To the Use of Land

In nearly every instance water-power development on mountain streams involves the use of land on which the flumes, ditches, pipe lines, and power-houses are located. The water must be taken from the stream at one point and put back at another. It is also usually necessary to occupy land for reservoirs to store flood waters, in order that the power possibilities of the site may be fully developed. The total amount of water that is discharged by a stream throughout the entire year depends upon precipitation and temperature. The discharge of water in the stream at different seasons of the year depends upon the distribution of the precipitation and the storage capacity of the watershed. The capacity of a watershed to absorb and store water is influenced by the character of the soil and the steepness of the slope as well as by the surface cover. Streams are usually filled to overflowing in the spring and early summer, when the snows are melting, while in the late fall and early winter they may be nearly dry. Unless the flow is regulated by the storage of water it would be inadvisable, under these conditions, to construct a power plant of greater capacity than could be operated during the period of low flow. The reason for this is obvious. It is seldom that contracts can be obtained for furnishing power for only a part of the year, and to secure full development the maximum capacity of the plant must be maintained by means either of storage reservoirs or of auxiliary plants operated by steam. A power-producer may, by constructing storage reservoirs, operate throughout the entire year a plant of, say, 20,000 horsepower, whereas, were it not for the storage of water, it would be impossible during part of the year to develop more than 10,000 horsepower.

While the development of energy from natural flow and fall is most readily understood and appreciated, the utilization of flood waters is of no less importance as a means of conservation, and is given equal consideration by developers and engineers. The topography of the National Forests naturally furnishes the conditions which are most essential to a reservoir site. Usually these are a contracted point favorable for a dam, as at the entrance of a canyon; a sufficient area for a storage basin behind it; the rock and other building material necessary for the construction of the dam, and the grade of river below supplying the fall necessary for the development of power.

PUBLIC CONTROL OF WATER-POWER

Public control of water power has been exercised by the individual States in this country for decades and in European countries for more than half a century. The laws of Pennsylvania date back to 1874, of Italy to 1865, and of France to 1851. The early Pennsylvania statute had reference merely to the requirements of incorporation, the issuance of franchises, and the right of appropriation. The early French and Italian laws went further, and prescribed the conditions under which the franchises might be exercised. The principle of regulation has, however, had its greatest development, both at home and abroad, within the last ten or fifteen years. Regulation to a varying degree is now exercised in Sweden, Norway, France, Italy, Switzerland, New Zealand, Australia, Japan, in all the Canadian provinces, by the Federal Government of the United States, and by such States as Maine, New York, Pennsylvania, Wisconsin, Oregon, and California.

In some instances control is exercised by local authority, as in the Canadian provinces; in others it is exercised by National authority, as in most of the European countries; in still others it is divided between local and National authority, as under certain conditions in Switzerland and on the public lands of the United States. In some instances the control consists merely in fixing the conditions of receiving and holding a permit or lease. This is the general method employed by the several States and by the United States Department of Agriculture. In other instances a more or less close supervision is maintained over the construction and operation of the works, as in Italy and Switzerland. New York State, in addition to maintaining general control, proposes to construct and lease storage reservoirs and other water-power works. The Province of Ontario has constructed and is maintaining and operating transmission and distribution works, and is purchasing electrical power and selling it to municipalities.

As illustrative of the several methods and degrees of regulation now exercised, a brief outline follows of the policies which have been and are being followed by Italy, Switzerland, New York, and Ontario.

Italy.

The first general water law of Italy was approved on March 20, 1865. It was partly repealed as inadequate, and supplemented by other acts. An act was finally passed on August 10, 1884, which, with the regulations issued under it, particularly those of November 26, 1893, constitute the code concerning water and water-powers.

For the diversion of public water "a concession" is required, for which an annual rental is paid. The papers of concession limit the amount of water diverted and the conditions of diversion, use, and restoration, give rules relating to agriculture, industry, and public health, and fix the time for beginning and completing construction. The concession is limited to 30 years, but is renewable in favor of the concessionaire 30 years longer. If during the period of concession the regimen of the stream is changed in the public interest, the concessionaire is not entitled to indemnity, but only to a proportionate reduction of the annual rental. Customarily the applicant first in time is granted the concession, but in consideration of a higher use the grant may be made to a later applicant. Furthermore, if the public interest is involved all applications may be refused.

Switzerland.

Until 1908 each of the twenty-five Swiss cantons had its own legislation concerning the development of water-power within its boundaries. The development of electric power projects in two or more cantons made a division of authority among the cantons more and more unsatisfactory. On October 25, 1908, an amendment to the constitution placing the control of water-powers within the hands of the federal government was passed by a referendum vote of more than five to one.

Concessions now granted by federal authority are subject to the right of the nation or of the canton to withdraw the concession without indemnity whenever the need for its use in the public service shall arise. All concessions are granted subject to the right of the nation to impose such rental as it may deem just, and are subject to forfeiture for non-use.

New York.

Following an agitation of more than 10 years, the New York legislature in 1902 created the Water Storage Commission to investigate causes of floods and to make recommendations for their prevention. The commission in its report of 1903 recommended State supervision and control by public commission. This recommendation was adopted by the legislature, which took the further step in 1907 of establishing the principle that new grants of water-power rights should be made only upon the basis of an annual rental to the State, readjusted at specified intervals. The legislature also passed in 1907 what is known as the "Fuller Act," which directed the State Water Supply Commission to collect information relating to water-powers of the State and to devise a general plan

for the progressive development of such water-powers. Up to the end of 1910 the commission had expended $100,000 in the investigation of water-powers and in making detailed surveys and reports, and had submitted a draft for a general law providing a scheme for the conservation and development of water-powers by the State.

By acts of the legislature of 1911 the State Water Supply Commission was succeeded by the State Conservation Commission, and a special committee was appointed to investigate water storage and water-power development. This committee reported on January 29, 1912, but the legislature adjourned recently without passing any acts affecting the subject.

Ontario.

The Province of Ontario until 1898 made no reservation of water-powers in grants of public lands. A law passed in that year reserved all water-powers of more than 150 horsepower minimum, and provided for the leasing of such powers upon the payment of an annual rental, development within a specified time, supplying surplus water to those requiring it upon conditions and rates to be determined by the government, and full development whenever the government decides that there is a demand for the power.

Complaint was made in 1900 that the water-powers of the province were being monopolized and that excessive rates were being charged for power. The Hydro-Electric Power Commission of Ontario was accordingly created in May, 1906, to report on water and electrical power, and upon power and lighting needs. With the authority of the Lieutenant-Governor-in-Council it may purchase, lease, or condemn lands, water-powers, water privileges, electric current and power, and distributing plants, which it may also operate. It may make contracts with public and private corporations to supply power or light, controlling the rates charged by them, and it may borrow money for these objects.

The commission has already constructed and is operating 281 miles of 110,000-volt main transmission and 180 miles of distribution line, buying current from the Ontario Power Company at Niagara Falls at $9 per horsepower per annum for all amounts above 25,000 horsepower. The rates charged the municipalities vary from $18.10 to $29.50 per horsepower per annum, according to distance, and at present 21 municipal corporations are supplied with an aggregate of 30,500 horsepower.

The rates are determined by adding to the contract price (1) 4 per cent per annum upon that part of the construction cost properly chargeable to each municipality; (2) an annual amount sufficient to create a

sinking fund for the payment of such construction costs within 30 years, and (3) a proportionate part of the line loss and the maintenance and operating expense.

EXISTING LEGISLATION AFFECTING WATER-POWER DEVELOPMENT ON NATIONAL FORESTS

The earliest legislation providing for the use of Government land for water-power development may be found in the act of Congress approved May 14, 1896 (29 Stat., 120), which authorized the Secretary of the Interior, under general regulations to be fixed by him, to permit the use of public lands and certain reservations for rights of way for the purpose of generating, manufacturing, or distributing electric power. It should be noted that the act does not contemplate the grant of rights of way amounting to easements, but merely authorizes the Secretary of the Interior to permit the occupancy of public lands and reservations. This act was followed by the act of February 15, 1901 (31 Stat., 790), which provides for the issuance of permits for rights of way for miscellaneous purposes involving the use of water, including the generation and distribution of electric power. Any permission given under it may be revoked by the Secretary of the Interior, or his successors, in his discretion. It especially provides that it shall not be held to convey any right or easement or interest in, to, or over any public land, reservation, or park.

An act approved May 11, 1898 (30 Stat., 404), provides that rights of way over the public lands and reservations secured for the main purpose of irrigation may be used for water-power development as subsidiary to the irrigation use, and an act approved February 1, 1905 (33 Stat., 628), grants rights of way over Forest reservations for municipal or mining purposes and for the purposes of the milling and reduction of ores. An act approved March 4, 1911 (36 Stat., 1253), authorizes the granting of an easement on National Forest lands for transmission lines for periods not exceeding 50 years, under general regulations to be fixed by the Secretary of Agriculture. A special act approved May 1, 1906 (34 Stat., 163), granted the Edison Electric Company, a Wyoming corporation, rights of way in California, but provided that the grant should remain in effect only during such period as the Secretary of Agriculture might fix immediately after the passage of the act. The Secretary fixed the period at 40 years. The act also authorized the Secretary of Agriculture to charge the company such reasonable amount as he might consider proper as compensation for the privilege granted—that is, the right to occupy lands of the United States.

The act of June 25, 1910 (36 Stat., 847), authorizes the President to temporarily withdraw from settlement, location, sale, or entry any of the National Forest lands, as well as public lands, valuable for water-power sites, and to reserve them until the withdrawal is revoked by him or by an act of Congress. This act provides that lands withdrawn thereunder shall be subject to exploration, occupation, and purchase under the mining laws of the United States. Since the National Forest lands are already reserved and withdrawn from appropriation under any of the public land laws except the mineral laws, the settlement act of June 11, 1906, and the rights-of-way acts, the only effect of this act, in so far as National Forests are concerned, is to prevent the appropriation under any of the rights-of-way acts of National Forest lands valuable for water-power development.

DEVELOPMENT OF A WATER-POWER POLICY ON NATIONAL FORESTS

Founded on Law

The law of 1897, which defines the purposes for which the National Forests are created, namely, to secure favorable conditions of water-flow and to furnish a continuous supply of timber, also specifies that the Secretary of the Interior may make such rules and regulations as will insure the objects of such reservations and will regulate their occupancy and use. When in 1905 the administration of the National Forests was by law transferred to the Secretary of Agriculture, Congress made further provision respecting the use and occupancy of National Forest land by specifying the disposition to be made of money received from the use of such land and resources. It is evident that Congress contemplated that all the resources of the Forests should be available for use, provided such use was not inconsistent with the purposes for which the Forests were created and that such use should be regulated by the Secretary in charge; and it is also evident that express provision was made for the payment of a charge by users of resources or lands as a part of the regulation of use.

Early Regulations

On July 8, 1901, regulations under the right-of-way act were promulgated by the Secretary of the Interior, prescribing the manner in which an application should be prepared and filed, and the procedure which would have to be followed after it was filed in order that it might receive the approval of the Secretary. A formal permit was not issued,

the Secretary merely noting on the map showing the location of the project an endorsement in the following form:

> "The use of the right of way shown on this map is hereby permitted in accordance with the provisions of the act of Congress approved February 15, 1901, and the regulations, present or future, thereunder."

Jurisdiction over the National Forests was transferred from the Secretary of the Interior to the Secretary of Agriculture on February 1, 1905. The act making the transfer provided that the Secretary of Agriculture should thereafter execute or cause to be executed all laws affecting public lands reserved as National Forests except such laws as affect the surveying, prospecting, reconveying, locating, appropriating, entering, relinquishing, or patenting of any such lands. These laws were to be administered by the Secretary of the Interior. It was agreed between the two Secretaries that the act of February 15, 1901, in so far as National Forest lands were affected by water-power projects, should be administered by the Secretary of Agriculture. (33 L. D., 609.)

The earliest form of permit issued by the Department of Agriculture for water-power development was one already in use for various kinds of occupancy, such as roads and trails, pastures, summer residences, etc.

Following the practice of charging for timber and for the right to graze stock within National Forests, it was early decided that permittees using land for commercial water-power development ought to pay the Government for the occupancy and use of the land. The Attorney-General held (25 Opinions, 470; 26 Opinions, 421) that since Congress has conferred upon the Secretary of Agriculture the right to grant or to withhold permission to use National Forest land, the exaction of a reasonable charge and the attachment of such conditions to the permission as he sees fit in the public interests was an entirely proper condition to the issuance of a permit. It was held throughout that since the National Forests were created for the benefit of all the people and are protected and maintained at the expense of the general taxpayers of the nation, the developer of water-power on National Forest land for private gain who enjoys special benefits from such protection and maintenance should bear a reasonable share of the cost. If the lands were in private ownership and a water-power developer were obliged to purchase or rent them, he would have to pay what they are worth for such use. Any rental charge imposed by the Government might, therefore, appear to be reasonable if it did not exceed a fair interest charge on the value of similar land purchased or leased from private owners. It has been

urged that the United States should make no charge for the use of the land, since such charge would ultimately be borne by consumers of the electric power who live in the territory immediately adjacent to the water-power. This contention is not convincing, since both developer and consumer enjoy special benefits, and neither should be permitted to enjoy the benefits of natural opportunities without a fair return to all for the special privileges thus accorded them. Furthermore, the electrical energy obtained from water may be used within a radius of 200 miles from the place where the water-power is found. Sometimes the water-power is found in one State and the electrical energy used in another. Under existing law 25 per cent of the rental charge paid by the developer to the Forest Service goes to the county where the land used is situated in lieu of taxes. If the rental charge is not made, the developer escapes the payment of what amounts to a county tax and the county is deprived of the revenue it would enjoy were the land in private ownership.

Some of the water-power developers on National Forest lands have contended that the rate of charge for the use of public land should be limited to the expense incurred by the Government by reason of the use of the property by the permittee. The representatives of the Government considered also the value of the land to the permittee for the use to which it is put in endeavoring to arrive at the proper basis for a charge. However, in determining the amount of the charge it has always been the intention to make it reasonable under all circumstances, and it has never been intended that the charge be imposed for the primary purpose of obtaining as much revenue as possible. No schedule of charges was at first prepared. The first few water-power permits provided for a flat annual charge, varying from $10 to $100, depending on the magnitude of the project. It was early evident that some proportionate basis for this charge should be adopted. It was finally determined that there should be a fixed construction charge, based on the amount of land occupied, which should run from the time the permit was issued. This charge was established at $5 per mile per annum for conduits and transmission lines and $1 per acre per annum for reservoirs. It was determined that there should also be a conservation charge based on the higher value of the land by reason of the protection of the watershed, which additional charge should begin when the plant was constructed and in operation. It was held that the protection of the forest cover was a benefit to water-power permittees, in that it provided a more even flow of water and prevented erosion and the filling of the reservoirs with silt. Therefore, in fixing the charge, two factors were

considered: First, the protection of the watershed from which the water was obtained, and, second, the fall on National Forest land which made the water valuable for power development. The protection of the watershed and the fall obtained were deemed factors of equal importance. If the conservation charge for a given plant should be fixed at $1,000, half of this amount would be considered as due to watershed protection and the other half to fall. If a part of the watershed or a part of the fall was not on lands owned by the United States, the conservation charge would be reduced by a proportional amount.

The purpose of making a charge before a plant was put in operation—that is, the construction charge based on the acreage in the reservoir and mileage of a conduit—was to discourage speculative withholding of water-power sites by those who did not intend to make a development themselves, but sought to control sites in order that they might dispose of them to actual users. This requirement, it was believed, together with one that the plant should be constructed and put in operation within a specified time, would tend to prevent speculative holding of water-power sites.

The earliest permits also contained certain conditions having for their object the protection of the forest. These related to the removal and destruction of brush so as to lessen the danger from fire, the payment for merchantable timber destroyed, and the building and repairing of roads and trails necessitated by the construction of the works.

A brief experience with permits providing for an indefinite charge, as was the case when the amount of conservation charge was not fixed, but left to future adjustment, showed that they were unsatisfactory to permittees who were obliged, in financing their projects, to show the financiers just what charges of every character the project would have to meet. After several conferences with representatives of companies which were proposing to make large developments within the National Forests, a new form of permit was devised. This form of permit, like the one which preceded it, provided for the payment of a construction charge at the rate of $1 per acre per annum for reservoir and power-house sites and $5 per mile per annum for conduit and transmission lines from the time the permit was issued, and a conservation charge payable when the actual development of power commenced. The rate of the conservation charge was 2 cents per thousand kilowatt hours for the first year, as determined by reading the meter, increasing thereafter by 2 cents each year for four years. Subsequent to the first five-year period the rate was to increase by an increment not to exceed 2½ cents for each five-year period, so that in the period from the 36th to 40th

year, inclusive, the highest possible rate in any case would be 27½ cents per thousand kilowatt hours. The amount for any given period could, therefore, be determined by multiplying the output in thousand kilowatt hours by the rate. The rates of charge named in the permit were the maximum. Reductions from the maximum charges were made on account of the part of the watershed or fall not located on National Forest land. It was recognized that in many cases plants would be put in operation without having a market for their full capacity, and therefore, during the first few years of operation, the charge was made very small. It was provided that the clause respecting charges should remain in effect for 40 years.

Under the terms of the law, as has been explained, these permits were subject to revocation by the Secretary of Agriculture in his discretion. It is inconceivable, however, that this discretion would be used except for sufficient reasons, and then only in the interest of the public.

This form of permit was further amended during the fall of 1908 by more clearly defining the reasons for which deductions from the maximum charge should be made. An additional reason for deduction was also provided; this was that the permittee should not pay for power generated through the use of stored water. The purpose of this deduction was to encourage the construction of storage reservoirs, and thereby encourage a fuller power development of a stream. It is possible by proper meters and stream gauging to determine what portion of the water used by a hydro-electric plant is due to natural flow and what to storage. This new form of permit also provided for continuous operation of a plant after it was constructed, the purpose being to prevent a site from being partially used and the prices of electric power to the consumer forced up through failing to meet the market demands. It was further provided that the permit should be forfeited in case the works were transferred in any manner to a company in the nature of an unlawful trust whose purpose was to limit the output of electric energy or to restrain trade.

The objection to this permit from an administrative standpoint was that it required officers of the Government to keep a check on the output of the plants affected. The only men available for this work are Forest Rangers, and to attend to it efficiently they would be required to have a technical knowledge of electrical machinery, which could not ordinarily be expected, and the employment of specially trained men would be necessary. An additional objection is the unsatisfactory character of the meter reading as a final record of output.

Present Regulations

By the spring of 1909 the work of administration had developed to an extent which led to the appointment of a hydro-electrical engineer to study water-power development on the National Forests from an engineering standpoint and to devise new methods of handling the business under existing law. For nearly a year the engineer carried on investigations and studies on the ground. In addition to the data obtained in the field he had the benefit of the experience of administrative officers of the Forest Service who for several years had been administering the act and studying the problems involved. He was able also to obtain from engineers and others interested in water-power development data relating to the purchase price or rental of sites on private land and their experiences in the development of water-power on the public lands and elsewhere. As the result of these investigations a set of revised regulations was drawn up in the summer of 1910, and their adoption recommended by the Forester and the Solicitor of the Department. They were approved and promulgated by the Secretary of Agriculture on December 28, 1910, and are the regulations under which the act is now administered by the Department of Agriculture.

All permits are issued by the Secretary of Agriculture with the exception of permits for small non-commercial plants which the District Foresters are authorized to issue, since they involve the use of a comparatively small amount of power development, and it is the purpose of the regulations to make their acquisition as simple as possible.

The regulations provide for two kinds of permits which are designated "Preliminary" and "Final." The purpose of the "preliminary" permit is to give the locator of what is believed to be a valuable water-power site a preference right for a reasonable time within which to obtain the data and make the surveys necessary to prepare and submit an application for a final permit. The right obtained is somewhat analogous to the right a miner acquires by making a mining location. He has staked his claim, and is given a certain period in which to perfect it. No permanent rights to occupy land or construct works are secured until a final permit is issued, and this must be obtained within the period specified in the "preliminary" permit. But provision may be made for permitting such work as may be necessary to comply with State law regarding water appropriation. The requirements for obtaining a "preliminary" permit are exceedingly simple, and can be fulfilled by the applicant in a short time and at small expense.

Before obtaining a "final" permit the applicant is required to file certain data and maps which give detailed information with respect to the location, size, and construction of the proposed works. The data and maps, however, are such as would be obtained by any developer for his own information before undertaking to construct a large project. Furthermore, such data and maps would ordinarily have to be secured by the developer before he could finance the project.

The Secretary of Agriculture cannot, under existing law, bind himself or his successors in issuing permits for a fixed term. A final permit issued under the present regulations provides that unless sooner revoked by the Secretary, it shall terminate at the expiration of 50 years from the date it is issued. It provides also that it may be deemed to be an application by the permittee for a new permit to continue the use of the land at the expiration of the 50-year period under the laws and regulations then in force, thus granting the permittee a preference right to continue such use.

Permits are not transferable, but upon presentation to the Secretary of certified copies of sale, lease, assignment, execution of judgment, or other form of transfer of the properties or other rights of the permittee to the works constructed under a permit, and of the water and other rights necessary to the enjoyment of the use of such works, the Secretary may issue a new permit to the purchasers of the works, etc., for the unexpired term of the original permit.

Since under the act of February 15, 1901, the occupancy and use of National Forest land is the sole privilege granted, no attempt is made to adjudicate conflicting water rights, but the applicant is required to make a *prima facie* showing that he has a right under State law to divert and use water. This provision has no bearing upon the mooted question of Federal or State authority over water.

The present regulations classify the use of land for water-power development as either "non-commercial" or "commercial." The use is considered non-commercial when the works are owned and used solely by the permittee for one or more of the following purposes: In the operation of their own mines or in the milling and reduction of ores therefrom; as auxiliary to irrigation works owned and operated by the permittee; temporarily, in the construction of other works for which permission has already been granted the permittee; by municipalities for municipal purposes; or for such other miscellaneous uses as may be determined by the Secretary of Agriculture. All other uses are classed as commercial.

Permits for commercial plants are conditioned on (*a*) prompt and complete development and utilization of a site; (*b*) continuous operation to the extent of market demands; (*c*) payment of a reasonable charge to the United States for the lands occupied; (*d*) publicity with respect to the amount of power generated; (*e*) operation without restraining trade with foreign nations or between two or more States or Territories or within any State or Territory, and (*f*) protection of the National Forest occupied.

These conditions are as follows:

(*a*) Prompt and complete development and utilization of a site are secured when, within the period required for actual construction, works are constructed through which all the power needed to meet the present and immediately prospective public demands for power are developed. The amount of power available, the public needs, and the works to be constructed to obtain the contemplated development or utilization are determined by competent engineering investigations. The permittee is required to begin and complete construction within such reasonable period as seems necessary, taking into consideration the location and magnitude of the project. Provision is made for making a progressive development. A permittee who intends to construct a storage reservoir, and several miles below it a conduit and generating plant, may be allowed to construct the conduit and generating plant first, and after these are completed to commence construction of the reservoir.

(*b*) To guard against a plant not being put to its fullest beneficial use after it is constructed and in operation, permittees are required to operate continuously unless prevented by unavoidable accidents or contingencies. The Secretary of Agriculture, however, upon a full and satisfactory showing of reasons, may temporarily waive this requirement. If speculative acquisition and holding of sites before the works are constructed can be prevented, and utilization of the capacity of the sites can be secured in the construction of the works, there will be little danger that the works will not be operated, since the interest charged on the money invested will prove the strongest incentive to continuous operation to the full extent of the available market.

(*c*) Permittees are required to make an annual payment to the Treasury of the United States as rental for the Government lands used. The charge is based on the value of the lands for water-power development. This value is determined by ascertaining the amount of horsepower that can be generated at a site. The regulations provide that the maximum rate of charge shall be $1 per horsepower per annum on the estimated average annual output of the works. It is recognized that some time

is required to develop the market; therefore the rate begins at 10 cents per horsepower per annum for the first year of operation, and is increased 10 cents per year until the $1 charge is reached. In other words, the permittee has ten years at reduced rates to fully develop his market. The charge begins with the commencement of operation of the plant. To discourage speculative withholding of sites, however, both preliminary and final permits provide for annual payments from the date they are issued, such payments being at the same rate as those made after the plant is put in operation. These payments are applied as credits, so that in case the plant is completed and operation is begun in accordance with the terms of the permit, the permittee has deposits to his credit which will relieve him from making any further payments until these credits are exhausted. If the plant is not constructed the permittee forfeits these payments. He has, in effect, paid the Government for an option which he has held. No provision is made for the periodic readjustment of the rate, since it is the intent of the regulations that, when the permit is granted, the permittee shall know definitely the entire rental liability for the 50-year period during which the rates are to be in force. The charge for rental is not made on the theoretical capacity of the site, but on the estimated average annual output of the works permitted. "Power capacity" as used in the regulations means estimated average annual station output in electrical horsepower which, under continuous operation with reasonable load factor, is possible of development from all water available, therefore falling through effective head, with deductions for reasonable mechanical and electrical losses in generating machinery. The term "load factor" means ratio of average output to maximum output. After the deductions are made for mechanical and electrical losses in generating and for load factor, the capacity on which charge is based is in general considerably less than 50 per cent of the maximum capacity of the works permitted. Of course, in a great many instances a part of the works necessary to the operation of a plant may be located on private land. When this is the case, a deduction is made from the maximum charges proportionate to the amount of such land. It is recognized that the data on which power capacity is determined are often insufficient, and the permits provide for readjustment of capacity every ten years. The company having kept a record of its output and also a record of water measurements, a more equitable determination of power capacity can then be made.

(*d*) The books and records of a permittee, in so far as they show the amount of electrical energy generated by the works constructed under permit or the amounts of water used in the operation of such works,

are required to be open to the inspection of the Secretary of Agriculture or his representative. A permittee may also, during January of each year, be required to furnish the Secretary of Agriculture, in such form as he may prescribe, a statement giving the substance of the records and measurements in his possession.

(*e*) Works constructed under permit must not be held or used in restraint of trade. A violation of this condition would be sufficient grounds for the revocation of the permit.

(*f*) To protect the Forest occupied, the permittee is required to prevent and suppress forest fires, to dispose of all brush or refuse accumulating during construction, to pay for timber cut or destroyed on the right of way, to reconstruct any roads or trails which may have been destroyed, to build suitable crossings, to protect telephone lines, and to pay for all damage to the National Forests resulting from the breaking of conduits or dams.

The Forest Service maintains a field force fully organized to carry into effect the present regulations of the Secretary of Agriculture and to deal promptly and efficiently with all the users of the National Forests, including the developers of water-power. An application for a permit is filed with the District Forester in whose district the lands are situated. The District Forester has all the necessary administrative, engineering, and clerical assistance to enable him to conduct directly and promptly with the applicant all business relating to the application which falls within the scope of the regulations. A report on physical conditions on the ground is made by field officers, and a thorough investigation and a detailed report on the engineering phases of the proposed development are made by a competent hydro-electrical engineer. The application and these reports are reviewed by the Chief Engineer and by the Forester, and are submitted, with the entire record of the case and the Forester's recommendations, to the Secretary for final action.

PROPOSED LEGISLATION

Some prospective developers of water-power on the National Forests contend that the law should be so amended as to enable them to obtain patents to the water-power sites they desire to use, and that the acquisition of such titles should not be conditioned upon any right of the Government to regulate the subsequent development and sale of power or upon the payment of any compensation to the Government. Such developers are among those who contend that water-power and all other natural resources should be developed by individual enterprise without

Federal regulation or restriction. It is generally admitted that the laws now in force are inadequate to secure full development of water-power on the public domain; but in spite of the contention of those who desire to secure special benefits at the expense of the public, there is a marked trend of public opinion opposed to parting with the title to public lands which are valuable for water-power development and in favor of leasing such land, and of Federal and State regulation of water-powers. Objection to the permits issued under existing law was expressed by a representative of one of the largest water-power developers in the country in the following terms:

"What is the nature of this permit and what rights does the company really acquire under it? It obtains a right which is revocable at will, unassignable, therefore unmortgageable, subject to interference from mining claims, and which becomes void whenever any change is made in the status of the lands, either by transfer from the jurisdiction of one department to another or by the granting of the right of entry. This is certainly a very flimsy peg on which to hang an investment of several million dollars." (Page 95, Senate Document No. 274, 62d Congress.)

It is very evident, in the laws so far passed by Congress, that it was the intention to retain title to water-power sites on public land, and it is equally evident that such laws have made a mere territorial disposition of the lands preliminary to the enactment of laws establishing a fixed policy for the regulation of water-power development on such lands. During the past three years a large number of water-power bills have been introduced in Congress, but none of them were voted upon. The provisions of these bills varied widely, from an unrestricted grant to a license under regulation. Some proposed to grant the right of condemnation under State laws, while others proposed to transfer to the States the title to the sites with authority to grant rights of way under State regulations.

Easement Without Regulation or Compensation

H. R. 18965, 62d Congress, provided that easements for all rights of way which have been permitted pursuant to the act of February 15, 1901 (31 Stat., 790), shall be confirmed upon the filing of proof of construction with the Secretary of the Interior within six months after the date of approval of the act or the completion of construction.

Rights of Way and Subsequent Patent

A bill (S. 2661, 60th Congress) provided for a grant of rights of way, with authority to grantee to purchase and secure patent to the land used

at a price of $2.50 an acre after completion of the works; for payment to settlers whose rights are taken or injured by the construction of works; for the payment of a charge of $1 per acre and $1 per mile for the use of the right of way prior to securing patent, and for forfeiture of rights of way for non-use. It also provided that the obligations and benefits of the bill were to apply to all existing rights of way or permits.

Title by Condemnation under State Law

H. R. 17539, H. R. 23586, S. 8025, 61st Congress, each provided that lands of the United States, including National Forest lands, might be acquired by condemnation for any public purpose or use prescribed by the laws of the State or Territory where the lands were located, and permitted the United States to become a party to any suit or condemnation proceeding for such purpose.

Right of Way with State Regulation

H. R. 20979, 61st Congress, and H. R. 8778, 62d Congress, each provided for an outright grant of rights of way, for State control and regulation of rates to consumers, for a forfeiture for non-use, and for the payment to the Government of a fee not less than $1.25 nor more than $20 per acre for the land granted.

The obligations and benefits of these bills were to apply to all existing rights of way or permits.

Grants to States and Use under State Law

S. 5704, S. 7055, S. 7432, H. R. 11932, 61st Congress, and H. R. 18486, 62d Congress, each provided that any unappropriated public land not included in National Parks, Indian and Military Reservations necessary for water-power development, be granted to the several States wherein the lands are situated, in trust for the benefit of the people of said States, respectively; that the several States may by legislation provide for the use of said land upon terms prescribed by the States, respectively.

Leases

H. R. 19158, 60th Congress (the Agricultural Appropriation Bill for the fiscal year 1909), contained an item which was inserted on the recommendation of the Department of Agriculture, which authorized the Secretary of Agriculture to issue water-power permits on National Forest lands for periods not exceeding 50 years, irrevocable except for breach of conditions, and which provided that any sale or disposal of the

land or any mineral location thereon should be subject to such permits. This item was stricken from the bill in the House on a point of order.

H. R. 23702, 61st Congress, provided that permits for the occupancy and use of lands in National Forests, National parks, Indian and other reservations and the unreserved public domain of the United States may be issued under the act of February 15, 1901 (31 Stat., 790), by or under the authority of the Secretary of the Department charged with the custody and control of the lands affected, for such period not exceeding 50 years as such Secretary may prescribe, and during such period may be irrevocable except for breach of conditions.

S. 10794, 61st Congress, and H. R. 751, 62d Congress, were identical, and provided that permits granted under the act of February 15, 1901, shall be for a fixed term of 50 years, irrevocable for the term except for breach of conditions thereof; that any patent, sale, or disposal of the land or any mineral location thereon shall be subject to such permit; that the permittee might have a preference right to a new permit for a further period not to exceed 50 years, subject to the laws and regulations then in force, and that such permits shall be assignable or transferable with the assent of the Secretary of the Interior.

S. 4714, 61st Congress, provided for withdrawal from all forms of entry of lands valuable for water-power development; for a license for the exclusive use of sites for periods not exceeding 30 years; for assignment of such rights; for the payment of an application fee of 10 cents for each horsepower which may be developed at such site; for the payment each year of a fee to be fixed by the Secretary of Agriculture of not less than one-half of one per cent or more than one per cent of the gross receipts of the preceding year, with a readjustment at the expiration of each ten-year period; for the payment of a fee after the expiration of ten years from the approval of the application of not exceeding $1 per horsepower per annum for the power which, in the judgment of the Secretary, may be developed at such sites in excess of the amount actually developed; for authorizing the Secretary to fix maximum rates to consumers and for the enforcement of such rates; for forfeiture of license; for non-use and for non-payment of fees; for reëntry after forfeiture of license or for a new license at the expiration of the 30-year period; for publicity of records, and for extending the provisions of the bill to all existing water-power rights.

S. 4733 and H. R. 22631, 61st Congress, are identical, each providing for withdrawal from all forms of entry of any of the public lands and reservations for public uses; for the classification of lands so withdrawn as agricultural, irrigable, dry-farming, timber, coal, mineral, National

Forest, and water-power lands; that lands classified as National Forest lands not valuable for water-power should continue withdrawn in accordance with existing law; the lands classified as water-power lands should not be sold or disposed of, but might be leased by the Secretary of the Interior for terms not exceeding 25 years, for a rental of not less than one per cent for the first ten years, two per cent for the next ten years, and three per cent for the remaining five years of the gross earnings from the operation of the water-power; that the lease should prescribe the time within which development of the power should begin and be completed; that the lease should prohibit violations of the acts to protect trade and commerce against unlawful restraint and monopolies (26 Stat., 209), and for forfeiture of the lease for violation of its terms.

S. 5486, 61st Congress, provided for classification and withdrawal of reserved and unreserved public lands more valuable for power development than for other uses; for granting a lease for a term of not exceeding 50 years, upon payment of an entry fee of not exceeding $1,000 and on condition that all water rights acquired by the applicant be made appurtenant to the lands, and upon conveyance to the United States of the rights of way necessary for the complete works in so far as they pass over private lands; that the lessee should pay an annual charge at such rate per horsepower developed as may be specified in the lease, with a readjustment of such rate every ten years; that the entry fee be credited to the amount required to be paid annually for the leasehold privilege; that the maximum rates to be charged to the consumers of the power developed should be fixed in the lease; that the lease should be forfeited for failure to make development within the period prescribed in the lease, to operate continuously, or to pay for the leasehold privileges as provided in the lease, or for entry into any agreement or combination to limit the supply of the electrical current; that at the expiration of the lease the Secretary will appraise the land and the improvements thereon separately, and offer the lessee a new lease for a period of not exceeding 40 years on equitable terms based on such appraisal, and if such lessee should decline a renewal the leasehold privileges will be sold at public auction at an upset price to be based on the appraisal of the privileges and improvements, and the original lessee be compensated to the extent of the appraised value of the improvements only.

During January, 1911, the urgent need for a solution of the problem of securing full development and of administering water-power sites on public lands led the Secretaries of Agriculture and the Interior to appoint a joint committee representing the two departments to study the

problems in the light of the experience of both departments in administering the present law, and to suggest a basis for recommendations for congressional action. The committee was composed of the Forester, the Solicitor, and the Assistant Forester in Charge of Lands on the part of the Department of Agriculture, and the Director of the Geological Survey, the Commissioner of the General Land Office, and the Law Officer on the part of the Department of the Interior. On January 19, 1911, the committee submitted a report recommending that the head of each executive department having jurisdiction over and custody of land needed for water-power development be authorized and empowered to lease, for periods not exceeding 50 years, any part of the public lands, National Forests, or other reservations or National parks, when not incompatible with the public interests or with the purpose for which such lands were reserved or such parks were created, such leases to be irrevocable for the term except for breach of conditions thereof or of regulations not inconsistent with the terms of the lease, or for persistence in charging users a rate for power declared excessive by the Supreme Court of the State where the land is located or where the power is sold. The report recommended that the heads of the said executive departments be authorized to promulgate joint and uniform regulations for the administration of such water-power development, including a reasonable charge for the occupancy and use of such lands. It recommended that such leases be assignable and transferable with the consent and approval of the head of the department having jurisdiction and control of the lands affected; that the lessee should have a preference right to the renewal of the lease for a further period of not to exceed 50 years when not incompatible with the public interests, and that provision be made for reëntry by the Government, and, after reëntry or after the termination of the original lease, for a new lease to another lessee upon the payment to the original lessee of the value of any part of the works which are available and serviceable at the date of the new lease. It recommended that the President be authorized and empowered to withdraw such leased land or any public lands designated as valuable for water-power development from all forms of disposal under any of the public land laws except so far as such disposal does not interfere with their use for water-power development. The intent of the latter provision is that, in so far as possible, lands valuable for water-power development and also for mining or settlement may be used for both, the water-power use to be recognized, however, as the dominant one.

On February 2, 1911, a bill (H. R. 32399, 61st Congress) was introduced, which embodied practically all the provisions recommended in

the report of the joint departmental committee, but specified further that the scope of the uniform regulations established jointly by the Secretaries of Interior, Agriculture, Commerce and Labor, and War be limited in the bill to the construction, maintenance, and operation of the works, the transfer, assignment, cancellation, and renewal of the lease, the qualifications of the applicant, the evidence of appropriation of water by the applicant, the form of application, examination, and inspection of works and records, the removal of timber, stone, and earth, the building and repairing of roads and trails, the treatment of Government property and permittees, the prevention and suppression of forest fires, the damages, the rates of charge to lessees, the measurement of capacities, the forfeiture, reëntry, affidavits and certificates, the sale of power to the United States, and to others when not inconsistent with local laws, and such matters as to them should seem fit in connection with the purpose of the act. The bill further provided how moneys arising from the lease of such lands shall be disposed of, and directed that copies of the regulations adopted by the Secretaries be transmitted to Congress as soon as practicable, and that annually a detailed report of all power developments under the proposed law be submitted to Congress. On March 2, 1911, this bill, with slight modifications in the language, was reintroduced as H. R. 33000.

A bill (H. R. 19858, 62d Congress) was introduced on February 10, 1912, which contained in somewhat different language all the provisions of H. R. 33000, 61st Congress, and in addition provided for a board consisting of one member each appointed by the Attorney-General, the Secretary of War, the Secretary of the Interior, the Secretary of Agriculture, and the Secretary of Commerce and Labor, to determine before the granting of any lease that it was compatible with the prompt, complete, and orderly development of the stream or streams affected thereby for domestic use, power, irrigation, and navigation; the bill also provided that all moneys received from leases, after deducting the cost of administration, shall be expended on rivers and streams for the improvement of water-power, domestic water supply, irrigation, and navigation.

A bill (S. 6795, 62d Congress) was introduced on May 13, 1912, which provided that the Attorney-General, the Secretary of the Interior, and the Secretary of Agriculture shall jointly formulate and publish uniform rules and regulations under which the head of the executive department having jurisdiction and control of reserved or unreserved public lands may lease such lands, for periods not exceeding fifty years, for the purpose of constructing water-power works thereon—when such

leases are in harmony with the public interests. That the rules and regulations shall provide for prompt and full development and continuous operation; for a reasonable rate of rental; for enforcing compliance on the part of the lessee with the laws of States; for negotiations for a renewal of the lease not more than ten nor less than five years prior to its expiration; for the valuation and compensation for the physical properties upon the termination of the lease; for accurate reports by the lessee covering the cost, rates of service, and profits; for control of capitalization, and for such other conditions and requirements as may be necessary to fully protect the public interests. That in case the Government shall itself take over the properties of any of the lessees, or shall, upon expiration, transfer their leases to other parties, it shall pay or require its new lessees to pay the reasonable valuation of all properties taken over or transferred, including all work, equipment, structures, and property located or acquired, valuable and serviceable, including the transmission system from generating plant to initial points of distribution, such reasonable values to be determined by mutual agreement between the head of the department and the lessee, and in case they cannot agree, then by condemnation proceedings in the United States circuit court; that any lands included in any proposed lease shall, from the date of filing the application, be reserved from location or entry, provided that location or entries under the mining laws may be allowed, so far as the same will not impair or destroy the use of the lands for water-power development, and when so located or entered the water-power shall be the dominant use—and provided that the President may restore such lands to their prior status; that leases shall not be assignable nor transferable except upon the written consent of the head of the executive department having jurisdiction; that in respect to every lease the Federal Government reserves the right to control the charges for service to consumers in the event that the laws and authority of the State or municipalities where the service is being rendered prove inadequate to protect the public interests; that all lands of the United States chiefly valuable for the development of water-power are reserved from all forms of entry, and that the head of the department having control may elect and designate, and list the same, and that no lands so listed shall be disposed of except upon the conditions that the water-power rights are reserved in perpetuity to the United States, which reserved right shall be expressed in the patent, and the President may revoke such designation as to any lands not under lease; that if any holder of a lease injure or damage, by the erection of works, the lawful possession of any settlers, the lessee shall be liable to the party injured for such

injury or damage; that the regulation shall be transmitted to Congress, and that the head of the department shall make a report to Congress annually of each lease issued during the year, the number in force, the names of lessees, terms, location and amount of land occupied, capacity of plant, rates and amounts of rental charges, and such other factor as Congress may require.

CONCLUSIONS

There are but three main factors to be considered in promoting water-power development on National Forest lands, viz., the engineering problems, the security of the investment, and the protection of the public interests. Legislation cannot affect the first, but is designed to provide for the second and third.

The security desired by investors through legislation includes the prevention of confiscation of capital invested in the works, freedom from restraint in securing a maximum of return for power sold to consumers, and exemption from the payment of any rental or purchase price or other charge for the public lands used in generating the power.

The protection of the public interests through legislation desired by the Government includes the prevention of speculative withholding of development of power sites, the fullest development and beneficial use of natural resources, a proper return to the general taxpayer of the nation for special benefits derived from the use of public property, and reasonable rates and efficient service to consumers.

In analyzing the bills which have been introduced in Congress since the enactment of the existing laws, those provisions which were designed to give security to the investment can be easily distinguished from those which give protection to the public interests, and may be summarized as follows:

To grant easements for rights of way upon filing proof of construction.

To grant rights of way, with authority to grantee upon completion of construction to secure patent to the land used.

To authorize the acquisition of public land for power development by condemnation under State laws.

To authorize the heads of executive departments to execute leases for the use of public lands for power development thereon, such leases to be for a fixed term of years and to be irrevocable except for breach of conditions; such lessees to have a preference right to a renewal of such leases for a further fixed term of years, subject to conditions expressed in the

law, to have the right to transfer or assign such leases and to receive compensation for improvements upon the termination of such leases.

To make the patenting, sale, or disposal of any public lands covered by such leases for water-power development thereon subject to such leases.

The provisions in these proposed laws which are designed to protect the public interests are as follows:

That lands valuable for water-power development shall not be patented, sold, or disposed of, but shall be leased, and that such leases shall be forfeited for violation of their conditions or of the requirements of law.

For authority to require the fullest beneficial use and to prescribe the time within which the development shall begin and be completed, and for requiring continuous operation thereafter.

For requiring the payment of an annual rental charge for the use of the land.

For requiring that all water rights acquired by the lessee used in the development be made appurtenant to the public land used.

For requiring that all rights of way necessary for the complete works, in so far as they pass over private lands, be conveyed to the United States.

For payment to settlers whose rights are taken or impaired by the construction of works, and to the United States for any damage to public property resulting from the construction or operation of the works.

For authority to require the lessee to prevent and suppress forest fires.

For prohibiting any agreement or combination to limit the supply of electrical energy, or any violation of the act to protect trade and commerce against unlawful restraints and monopolies.

For control and regulation by the heads of the executive departments or by the States of maximum rates and service to consumers.

For the keeping of records by the lessee of stream-flow and of the amount of power developed, and for the publication of such records.

For annual reports to Congress by the heads of the executive departments of all power developments on public lands.

In conclusion, it appears from the representations of the developers and the experience of the department in administering the present laws, that the water-power resources of the National Forests will not be fully utilized until there is a settlement of the vexatious questions as to whether the water-power sites on the Forests shall be owned and controlled by the Government or shall be allowed to pass into private owner-

ship to be developed without governmental regulation and control, and whether the appropriation of water for such development shall be controlled by the Federal Government or by the State. These questions can be finally settled only by the enactment of a law giving protection alike to the public interests and security to the investment.

DISCUSSION

WALTER L. FISHER, J. H. FINNEY, PHILIP P. WELLS, JOSIAH T. NEWCOMB

WALTER L. FISHER: The subject has been pretty broadly covered in this respect. As I understand, there is now going on between the two departments conferences with a view of working out some uniform regulations in the two departments, so that we will follow the same practice in each department and secure uniformity, and that, of course, has naturally led to some discussion of the fundamental principles that underlie the question of water-power development, and we have informally discussed at considerable length at one time or another these questions at issue. That committee, I think, or the individuals who have the matter in hand, are making substantial progress, and I hope they will be ready to present for action by heads of the two departments at an early date some uniform set of regulations. Now, the water-power question goes pretty deep. I don't know whether the apprehensions that are sometimes voiced as to the failure of our fuel supply are justified; but it is quite apparent that the price of fuel is increasing, that the cost of power produced in that way is bearing more heavily constantly upon the public, and that there is a very large waste going on through the use of those forms of fuel in generating power such as coal, oil, or wood. Any fuel of that kind is destroyed in its consumption, and once destroyed it is forever gone.

With water-power, as we all know, to a very considerable extent at least, if not entirely, the water is renewed by rain and snow, and we can use over and over again power that is not otherwise used, so that the exact contrary of the first proposition is true. In the use of fuel, as coal or wood, we are indulging in waste. In the non-use of water-power, we are just as truly indulging in waste. So it is apparent that non-use and non-development are waste, just as much as use is in the first case. So it is to the interest of all of us that we shall settle on a policy that will permit vigorous and wise development of water-power.

Just what should be done is not so clear. There are the natural differences of view that exist between those who wish to use the resources of the country for the purpose of making a profit for themselves, and

the public, which wishes to see this development go on for the benefit of the public. In our present civilization we are relying upon the incentive of private gain for our progress. We are making an appeal to enlightened self-interest as the motive power of individual action, and as long as we adhere to it we must make the incentive effective, or we will not protect the public interest, and we will not get the development. So long as we look to those men for the development we must make it attractive. If capital can get more attractive terms in other fields, it is not going to be attracted by water-power development. On the other hand, in the effort to make the inducement an attractive one we may go much too far, and very materially damage the public interest. Great difficulty arises in creating a vested interest in water-power—an interest which is going to persist after a very considerable time, if not perpetually, and which will be exceedingly difficult to control by drastic regulation.

It will be found that grants, to be effective, will have to use the public highway, or will have to appeal to the State for assistance in such matter, and we will be justified legally and morally in imposing drastic regulation from the top.

Then, too, we ought to foresee, so far as possible, what are likely to be the public interests of the future, and protect those interests so far as we can.

How to reconcile these two interests is a difficult problem. The water-power people themselves—that is to say, the more influential who are now engaged in water-power development—are learning a great deal. They have come around to the conviction that they are going to be regulated from the top, if not otherwise, and they will stand a great deal better, will be treated more leniently, will avoid the friction and ill-feeling that is constantly aroused by these demands at drastic regulation, if they acquiesce in reasonable regulations, and many of them are prepared today to acquiesce in a form of statute by Federal or State governments that will accomplish pretty nearly everything that it is now clear we ought to accomplish. They are prepared to go pretty nearly as far as any of us ask them to go. Unfortunately some are associated with them that are not so enlightened, and the gentlemen who are asking for a little more are allowed to lead the fight. The men who think they can get the private interests a little more are controlling to the extent of preventing direct coöperation on the part of the power people. And that is the situation now.

We have found, in talking with some of their representatives (I think Mr. Wells will bear me out), a disposition on the part of these repre-

sentatives to go very far—one of the water-power men, especially, and I think if he is not checked by his lawyer he will be disposed to concede everything we ask him. It may be his attorney may scare him off by telling him he will have trouble in the future.

The great question of the future is not compensation. I think there is a difference between the owner of private property and the Government, which asks compensation for any such development as water-power.

Water-power which is generated on the public domain must either be used as a public utility and sold to the community in the form of power for electric energy, or it will be used by the owners of the water-power plant for their own purposes in direct manufacturing and in the sale of the products of manufacturing. We will probably be able to regulate public utilities easily. We will not, however, be able to regulate those powers which are being used in manufacturing directly or through a disposition other than a public utility, unless we make some restrictions in the grant, and there are therefore many reasons why we should put in provisions for compensation. In the experimental stages of any enterprise the compensation charge ought to be small, and I believe we should be very moderate indeed in our demands for compensation. But we should also reserve the right to regulate compensation in the future as conditions change. Of course, that ought to be coupled with some form of protection to the grantee, and the only suggestion made which seems to me effective is that there should be a provision in the grant that the compensation so exacted should not at any time be so large as to reduce the return on the investment to the grantee an unreasonable amount, and leave that question of what is a reasonable amount open to the courts or some other tribunal, where we can act in the light of future developments, reserving the principle at this time without deciding upon the details.

Very few grantees make any objection to provisions for prompt development. They recognize the soundness of the contention that when power is turned over it must be utilized, for by refusing to develop, and holding the power they could develop, they enable some great interest to demand unreasonable charges from the public. Also, they could hold the site undeveloped for speculative purposes. So the grantee practically conceded that development must be made within a reasonable time.

The provision with regard to regulating rates and service under local authority seems practically conceded where the power is sold to the public.

The main thing about which the contention arises today is over the compensation charge and over the length of the grant, *i. e.*, all these people very naturally—as you and I would in the same circumstances doubtless—would like to have a grant in perpetuity. They don't like to face the alternative of 50 or any other number of years from now having the grant run out, and then have to negotiate for a renewal. That is met by the suggestion that there ought to be provision for a renewal at the end of the grant or a provision that, if the lease is not renewed and the plant or power is continued in use, that the Government shall take over the plant, and pay to the corporation the appraised value of the property at that time or the value based on some other method of appraisal—that is a very difficult thing to get straightened out at this particular stage of public discussion. Now the principle is very easy to state, but you will notice that in one of the bills to which Captain Adams referred there is a provision for taking up the plant and the transmission lines also, and there is where the difficulty begins to come in. The distributing lines, the main transmission lines, may not be on Government land at all. They may be on the public highway, on State lands, or wherever you please. The investment in transmission lines and distributing stations is many times that in the main generating plant, and the difficult question is in determining how far you ought to go so as to protect the public interest at one end and the private interest at the other.

To make it clear: We are now transmitting power two hundred miles successfully, and there are negotiations now under way which, if successful, will electrify several hundred miles of main line railroad. That will show how far power development is proceeding. Now along comes a company that gets a permit on a stream, say in a National Forest, and it builds a plant and distributing lines carrying current two hundred miles. That, of course, means a radius of two hundred miles, or a stretch of 400 miles, possibly. Before the company gets through it may have at least several times as much money in its distributing system as in the power plant. Now, if you provide that the Government shall take over its plant if the grant is not renewed, and don't provide that the Government take over the whole system, where are you going to leave it? On the other hand, if the Government is compelled to buy the whole thing, that is a pretty big contract, and frequently the price would be prohibitive, or at any rate raise serious questions. It may be well to put the safeguard in right now, but it is a serious question how far we have to go before we get through. I think we can agree on some general principles, and we can go at least far enough so that we can

protect the interests that it appears ought to be protected now, and make it possible to protect in the future the interests that ought to be protected in the future.

The most hopeful thing I have seen recently is the report made by Senator Burton's committee, with a very considerable report of sixty-odd pages, which, while I could not say that I agree with it entirely, nevertheless goes farther than any other similar report from anything like so authoritative a source. It discusses the general subject in an intelligent way, and, whether perfunctorily or not, it is the unanimous report of the committee, which includes some who might not be there if they had carefully read the report.

J. H. FINNEY: I want to start out by saying that I appreciate very greatly the honor of addressing the Society. I didn't quite know my qualifications for talking about power on the National Forests because my experience has not been in that particular branch of power development. I think, however, it is a part of the whole problem, and a very important part, and I have some qualifications to discuss some of the features of the problem. I go pretty far back in electrical experience. I learned telegraphy thirty-two years ago, and I have been in the business ever since. I helped to build the Richmond Street Railway, and it was about the same time in 1886 or 1887 when the current generator was developed, and I sold it, little 50 kilowatts and 35 kilowatts, for a good many years. It was considered the wildest kind of a dream to develop electrical power. They even made provisions when they built the first canal to Niagara Falls to install water-wheels, so that if the electrical current failed they could locate enterprises there and supply them with water-power.

Now, I think I can say I know something about water-power. I know something of the early struggles, when we could only generate a couple of thousand volts, to the next-sized plant that used the enormous pressure of 11,000 volts, to the plants today, where are generated 140,000, and are distributing 200 to 250 miles from the generating plant. It has been a wonderful development. It has brought about a very serious condition in the last few years. It used to be, of course, that water-power was simply a local interest. A man who owned a water-power owned it. He built a mill and used the power to grind grain for his neighbors. As soon as he began to distribute power he became a public servant, and as he distributed it over wider areas he grew in importance as a public servant. He has not always been a good one. When he began going into navigable streams, when he was seeking water rights in National Forests

and on the public domain, it was only then he became a National problem and the water-power question became a National problem.

I have been very much concerned in forestry. Four or five or six years ago my studies as an electrical engineer led me into the advocacy of forests at the headwaters of streams. Since the Appalachian bill has been passed (and I am proud to say I had some work to do on it) I had some part in this conference Secretary Fisher has just talked about. And I agree with him that the report of the National Waterways Commission marks a very distinct advance in the proper thought on water-power development. I would like to recall a remark President Roosevelt made about five years ago. He said at the Conference of Governors:

"In matters that relate only to the people within a State, of course the State is to be sovereign, and it should have the power to act. If the matter is such that the State itself cannot act, then I wish, on behalf of the State, that the National Government should act. Take such a matter as charging rent for water-power. My position has been simply that where a privilege, which may be of untold value in the future to the private individuals granted it, is asked from the Federal Government, that the Federal Government shall put on the grant a condition that it shall not be a grant in perpetuity. Make the term long enough so that the corporation shall have an ample material reward. The corporation deserves it. Give an ample reward to the captain of industry, but not an indeterminate reward. Put in a provision that will enable our children at the end of a certain specified period to say what in their judgment should be done with that great natural value which is of use to the grantee only because the people as a whole allow him to use it. It is eminently right that he should be allowed to make ample profit from his development of it, but make him pay something for the privilege, and make the grant for a fixed period, so that when the conditions change, as in all probability they will change, our children—the nation of the future—shall have the right to determine the conditions under which that privilege shall then be enjoyed. Where that policy can be best carried out by the States, carry it out by the States; where it can be best carried out by the nation, carry it out by the nation. My concern is not with the academic side of the question. My concern is in the employment either of the principle of State rights or the principle of National sovereignty as will best conserve the needs of the people as a whole."

I believe that statement showed an honest intent, and that it is a platform upon which the Government and the seeker after water-power rights can both stand. Four years which have intervened are not entirely wasted. They have been very busy years on bills relating to water-power, yet I had no idea until Captain Adams said how many had been put up to Congress of the large number that had been introduced. There undoubtedly exists in the minds of the Federal Government, the State

governments, and the seeker after water-rights a better understanding of the problem, an understanding that will enable us to find the solution in time. I am not going to talk very much because Senator Newcomb is going to say something, and is more familiar with the situation than I am, but he is going to cover it from the standpoint of the public-service company—that is, companies supplying light, heat, and power to a very diversified group.

I should like to present what to my mind is a larger and more important point, the position of the developer who will himself be the user of power—as, for example, the man who makes carborundum, electrical steel, and other of these electro-chemical or electro-metallurgical processes—because I believe there will come from this type of user much the largest development, both in point of horsepower used and in value to be obtained from that use. The steam railroad, for instance, is just about beginning to consider the use of electricity. As the Secretary said, a main-line trunk system is considering the use of electricity for the operation of all main-line trains in the Sierras. It is going to do it, and it is only justified in doing it by getting cheaper and permanent power. There are 30 million horsepower dormant in the streams of the United States. I don't believe that 10 millions of that will be used for strictly public service in the next hundred years. I believe the other 20 million is going to be used to develop electro-chemical industry.

When we consider that 400 or 500 miles is the limit of transmitting current, and will continue to be the limit, because at the limit of 200,000 volts which would have to be employed we would reach the diametric strength of air, if we did not earlier reach the limit of capital. You couldn't keep the current on the wires at a higher voltage. Of course, that is higher than is now being operated. Now, 400 miles doesn't carry so very far from a great many of these powers, and yet every one of those powers could be used as the source of power for manufacturing, and the remoteness of it from the market and possible raw material really would not cut much figure as against the cheapness and permanency.

Niagara Falls was developed in 1893, yet it has not sold up to its capacity yet. It has not sold it in Buffalo or in Syracuse or a lot of intervening towns which it supplies. The largest use of Niagara Falls power is the local users at Niagara Falls. Take the Keokuk power in the Mississippi. They are going to develop 200,000 horsepower there. Outside of the relatively small amount transmitted to St. Louis, the bulk of it must be sold to electro-chemical users who come to Keokuk because cheap power is there. I don't intend to belittle the transmitting of power, but the most important use of transmitted power is the conservation of the

coal supply. That is the one most in view, the substitution of electrical power for steam-generated power. Surprising as it may seem, even in the territories served by big electrical power companies, the consumption of coal has not decreased. We supposed also that the use of electrical power for lighting in towns would drive the gas companies out of business. Yet the use of gas increases as the use of electrical power increases.

I would just like to call Secretary Fisher's attention to one thing, and that is that the cost of steam-generated power is steadily decreasing, and has a tendency to decrease for many years to come, due to improvements in methods of generating, and is not increasing with the gradual rise in the price of coal. As a matter of fact, the cost of steam-generated power has decreased 2½ per cent, while the cost of coal has only increased 1 per cent per annum. There can be no sudden substitution of electricity for steam. If we would instantly develop the 30 million horsepower we couldn't do anything with it. We couldn't sell a million horsepower of it. In other words, we couldn't force a market. It would take a very long stretch of years for the market to absorb all of it. I suppose it would not only cost six or seven billion dollars, but it would take a hundred years. It has taken twenty-five years to develop four million horsepower. The problem will be with us for a long time before it is finally all developed, so that I do believe we shall get the most beneficial use of water-power from the man who uses it himself in an electro-chemical operation.

I said in St. Louis recently that the electrification of steam railroads from water-power that might be developed on navigable streams would mean infinitely more to the nation in transportation facilities than if the money were spent on the streams for improving navigation. Of course, I referred to streams that are really power streams. I didn't mean the Mississippi, the Missouri, the lower Ohio, but streams like the upper Potomac, the Cumberland, the upper reaches of the Ohio. The money spent on dams for water-power development on such streams would be worth infinitely more for the electrification of steam roads than for navigation.

The situation reminds me of the fact that it is well to catch the rabbit, if you intend to have rabbit for dinner, before you have the dinner. Now, in this talk of regulation, wouldn't it be well for us to get together on some plan to get the water-power development started first and then regulate it afterward? We ought to have water-power development before we apply regulations. I have been trying to get before Congress and before the nation the underlying principle, and I have been working for a water-power policy which should be uniform, fair, and enlightened, which would

safeguard any rights that the people have—and I admit they have them—and at the same time should safeguard the vested rights.

I don't balk very much on vested rights. I believe if a man puts up millions of dollars in an enterprise that it is his, most of it. He is subject to State regulation, and he is wise to get under State regulation; but when he is regulated once that ought to stop it, and he ought to have some rights in the matter. One is the permanency of investment and repayment of the money that he puts in an enterprise if the grant is terminated. There is not a man in this room that would put money into a plant whose grant could be revoked tomorrow by Mr. Graves or Mr. Fisher. There isn't a man who would invest in a project that is not permanent. I believe the Federal Government should issue a franchise that while recognizing that the agency of operation would change, the structure itself, whether it be a dam on the public domain, a dam in the National Forest, or elsewhere, it is serving a useful purpose, and the dam that is generating electricity is going to serve a useful purpose long after all of us have disappeared. Now, if it is a navigable stream, and the Government grants a right to occupy the stream, and the Government says, Pay us a reasonable amount, I think that is all right, but let us make it a reasonable amount. If the Government is going to make us build a two-million-dollar dam and maintain it that is pretty fair compensation. You know in this matter the shoe is not all on one foot. It is quite a large lump of money to put into the project. The Government owns the lock, and it seems to me that if the Government lets us do the work and provide navigating facilities that did not exist before, that is pretty fair compensation. If that dam is necessary, if it is serving a useful purpose, if it is improving navigation, why should it ever come out? It might be modified to suit changes in navigation, but I can see no more reason to tear out that dam at the end of fifty years than I could for tearing up the lines of the Pennsylvania Railroad between Pittsburgh and New York. Somebody has got to operate the Pennsylvania Railroad between Pittsburgh and New York all the time. Take it in the National Forests. I think if a water-power company wants rights and it occupies land belonging to the public it should pay a rental on it. If the Government permits the use of its lands for transmission lines or for the building of dams or storage reservoirs it rightly should ask the company to pay rental. We pay $10 a horsepower on some of our Eastern projects to private land-owners, and there is no reason why the Government should not make a charge for it. But when you have done that, it seems to me, you have done all that is just. Give the other man a chance at the balance. I don't know just how many of you believe that water-power is a

gold mine. Water-power not only requires a very large amount of money in its development, but requires a very large amount of nerve. I have taken more than one elegant water-power scheme to financial friends only to have a hole kicked into it, and I was wrong. The graveyard is full of water-power plants that are not making money. I have in my territory here in the South an enterprise that has cost four millions of dollars, and it will take two million dollars more to complete it, and when it is completed it will be worth less than two million dollars. There are four million dollars in the hole already. You find these financial gentlemen who expect large returns are very critical of the business aspects of any of these projects, and the more restrictions you put on it and the more difficult it is to insure repayment, the more critical you are the less chance there is for development. We all realize that the present laws are absolutely inadequate. There should be a recognition that hydro-electrical power is a public necessity, and of very great financial benefit to the nation when it is made. It is wasted until it is made. You may have the finest water-power in the world, and as long as it washes over those rocks at Great Falls it doesn't do anybody any good. The States in which these powers lie are entitled to the benefits therefrom, and the powers should be developed with Federal limitations if the State safeguards its franchises. If the State wants it made, why in the world should the Federal Government say it can't be done except under conditions that make it impossible to be done? It doesn't seem to me that it is a question which should involve any mixed question of States and Federal control.

Unless we make the conditions attractive these electro-chemical men are going to Switzerland and Norway, where they can get cheaper power. It takes a large amount of capital to develop these projects, and, as former President Roosevelt says, capital is entitled to fair returns. I don't know any other group of men who take bigger chances than those investing in water-power. Capital must have attractive inducements if it is to invest in any enterprise so full of risk as is water-power. I believe when this viewpoint is reached by State legislators and Congress we shall see that a number of things we considered important are really underbrush, and when these matters are properly understood there can be brought about a broad Federal water-power policy acceptable to the water-power men.

I just want to read a paragraph or two from a letter from Edward D. Adams, presented at the hearings of the Waterways Commission:

"The danger of the situation lies in the effort already manifested in certain governmental suggestions to drive a bargain with capital, as though it was compelled to seek investment under the national leases proposed.

"The Government starts out to conserve and develop its natural resources through its paternity, but without contributing its credit or capital for the use of its people.

"It should not therefore place itself in position in effect to just not accomplish its desire, but should be too liberal rather than too strict in its inducement for other people's money to be invested for the ultimate benefit of the Government."

I don't believe there is any common sense in our present treatment of this matter. It seems to me that Government officials, legislators, and water-power seekers can all meet without very much difference of opinion on common ground. I am optimistic in spite of five years of dancing on Congress. I am really optimistic. I think that while we don't succeed very well in educating Congress, and Congress changes so frequently that it is a difficult matter to do it, that when we get the people most concerned interested we will see pretty promptly some reflection of it in Congress.

PHILIP P. WELLS: As a matter of public policy, all water-powers look alike to the man who is considering the power of the Federal Government. There is a distinction between those on land owned by the United States and others. There is one other reason for asserting Federal authority, and that is that the water-power may be developed in a navigable stream.

The subject tonight concerns only the publicly owned land, and it has been so thoroughly covered by Captain Adams that I shall confine what I have to say to a little reminiscence about the way the thing has grown in my memory. I entered the Forest Service in February, 1906, and began to get in touch with the water-power question in the summer of that year.

There was a general statute, the act of 1901, which covered water-power development on the public lands outside of the Forest and inside the Forest, and that statute, as you all know, was very unsatisfactory, and yet it still is the statute that governs these matters. It was unsatisfactory, primarily because it gave to capitalists who went into Government water-power a mere permit, which was revokable at the discretion of the Secretary granting it.

Now, when the Forests were transferred from the Interior Department to the Department of Agriculture by the act of February 1, 1905, this matter of water-power control in National Forests was transferred along with the rest, and the matter was taken up for consideration in the Forest Service before I entered it.

The act of May 1, 1906, as I recall it, made a special grant to the Edison Electric Co., a corporation created in Wyoming, but operating in the southern Sierras, and furnishing power to Los Angeles. This case had been carefully considered between Mr. Pinchot, representing the Forest Service, and the representatives of the company, and an attempt had been made to work out a statute that could be worked out as a model for a general law. That statute provided for a grant, the form of which was to be fixed by the Secretary of the Interior, and the only rental or compensation which the company was to pay was to be fixed year by year by the Secretary of Agriculture. My first notice of the water-power problem was in being informed as to the negotiations in this matter. That was worked out in the summer of 1906. I had no part in it, but heard of it.

There was a difference of opinion between the two departments. The Department of Agriculture favored a 99-year term, but the Department of the Interior, I think, objected to so long a term, but finally, I think, the matter was referred to the President, and a 40-year term was fixed as a result of that conference.

As to the rental fixed under that act, the Forest Service waited until it had worked out a basis for rental under the law of 1901, and then each year fixed the rental under each particular grant. The water-power rental was considered by Mr. Woodruff before he went over to the Department of the Interior, and after that it was handled in my office. It was fully recognized from the first that the act of 1901 was unsatisfactory, because it gave no fixed tenure, and the Forest Service did its best to get a fixed tenure for the companies. In the meanwhile work was done on the question of what compensation should be paid and what the basis of it should be. There was a good deal of confusion about it at first. The lawyers for the companies, and prominent among them the California lawyers, who were very active, asserted in very bold and bald terms that the State owned the water. We didn't have time to look it up very carefully, and in California it seems to me perfectly clear that the State courts have denied that right fully.

However, Mr. Woodruff cast about for some basis for rental charge, and the argument was used that the Forest Service, by maintaining the forest cover on the headwaters of streams, gave a very substantial and valuable thing to the power companies in equalizing stream-flow and maintaining better conditions to develop power in that way. The charge was theoretically based, therefore, on the conservation of water, and a name was given to it—the Conservation Charge. The early forms in the Forest Service, while these things were being worked out, were given to

the companies on condition that they should pay such conservation charge as the Forester might thereafter fix.

There was strenuous objection on the part of the companies' lawyers to this whole matter, and as a result of their requests the legality of this charge was to be submitted to the Attorney-General, and the preparation of the statement was well on toward completion when Mr. Woodruff went to the Interior Department. Then the matter came into my hands. Before he went over I consulted with him about the matter, and suggested that we put the charge on the basis of land ownership and rental rather than on the conservation of stream-flow, and in the statement to the Attorney-General, which was pretty well prepared by that time, the wording was rearranged so that the matter was stated in the alternative, first taking up the legality of charging for conservation and then stating the question of charge for the value of the land. The Attorney-General's answer sustained the power of the Secretary of Agriculture to make the charge. The companies were not satisfied with that result and took the matter to Congress. The so-called Crane-Mondell Bill in the first session, 60th Congress, was prepared by the water-power people, and introduced by Senator Crane in the Senate and by Mr. Mondell in the House, and the water-power people, a few days before its introduction, communicated with the President, sent him a copy, and asked for his criticism. It was transmitted to the Forest Service. The bill was criticised by us, and a memorandum prepared in which the ground was very strongly taken that the act of 1901 was unsatisfactory because it did not specify a fixed tenure, but that the Crane-Mondell Bill was objectionable because it gave tenure in perpetuity for a nominal compensation of $1.50 an acre. Less regulation was provided for in that bill than any water act with which I am familiar. The result of that was that the power people proposed a conference, and there was a conference held during that session. In the meantime we drafted in the Forest Service a clause providing for 50-year permits, and it was incorporated in the Agricultural Appropriation Bill in Congress in the winter of 1907 and 1908. Meanwhile this conference to which I referred was held in Secretary Garfield's office, and went on for ten days. There were representatives from the water-power people, bankers, lawyers from Boston, New York, California, and elsewhere in the West, and lawyers here in Washington, and they put forward the Crane-Mondell Bill as their program and we put forward the 50-year tenure as our program. The result of it was that we couldn't get together. Senator Flint was in those conferences, and did his best to get us together, and we couldn't get together at all. Thereupon the Crane-Mondell Bill made no prog-

ress, because it was thoroughly understood, as Senator Flint told the water-power people, that it would be vetoed even if it did make progress.

Our 50-year tenure scheme came up in the House, and, being new legislation, it was subject to a point of order, and the point of order was made by Mr. Mondell. So I think if there is anything the matter with revokable permits it is not on Congress, but on the companies.

As I say, no progress was made on either of these measures, and the matter drifted along until the close of the Roosevelt administration. In the meantime the Forest Service was going ahead, changing the forms, threshing out every case that came up in a practical way, and the permit gradually became less objectionable to the companies. New provisions were put in that seemed wise to the company, and finally we got into a pretty fixed form in the spring of 1909. Up to that time we had had no technical engineering assistance except such as came fortuitously and information picked up from the companies.

One of the questions which was given a good deal of consideration was whether some deduction should be made from the regular charge if the companies stored water, and a sort of promise had been made that some such deduction would be worked out, and finally it was worked out practically in the case of the Stanislaus Power Co., in California, and made general in the spring of 1909. The deduction was based on the transmission distance.

The Stanislaus permit was very important in another respect. We had required that the company should pay such conservation charge as might be fixed by the Secretary. As I recall it, the company had made some development under an earlier permit. At any rate, they were in the position of having made investments without knowing what they were to be charged. They had gone ahead and made developments, and then were afterwards asked to pay a charge. After threshing the thing over at great length, the matter was settled in this way: With respect to their new development, they should pay the regular charge, but with respect to the old development, they should be practically free from charge for 25 years. Our arrangements all contemplated a 50-year permit. That is to say, we talked as if there were going to be a 50-year term, although the Secretary had the right to revoke at any time. There was a charge of two cents a thousand kilowatt hours, which was purely nominal. That was in January, 1909.

Then the question arose as to what was to be done about a lot of permits which had been issued by the Interior Department without conditions before the power sites were included in the National Forests. The

rule we had worked out in the Stanislaus case—that is to say, make only the nominal charge for twenty-five years—was applied.

Those that had made no development were simply revoked; but where they had made actual development under the old terms, the terms in the Stanislaus case were applied. It took two months to work it out in the pursuance of this policy. The permits were all revoked, but the order of revocation stated that their occupancy should be continued until the new permits were given to them under the scheme I have just suggested. Those revocations caused a great deal of criticism, but they were not hastily made, and was an application of what had been done in the case of the Stanislaus company, and the Government officers thought it was an equitable adjustment, and since then it has been criticised as being too easy on the companies.

That pretty nearly covers what I have to say. There has been a crop of bills in every session of Congress since the Forest Service took over the matter. Captain Adams has recited most of them. One type of bill that he didn't particularly mention was that which subjects the lands of the United States to regulation from the State courts. Such a bill was introduced by Senator Keller in the 60th Congress.

In the Forest Service permit there was no attempt to regulate the price that the companies were to charge to the consumers or the service to be rendered to the consumers. In the first place, we couldn't cross that bridge until we came to it. In the second place, it was supposed that the States would look out for that. The matter was discussed two or three times between Mr. Pinchot and myself about inserting in the permit a provision that the permittee should promise to obey State regulation as to prices and service, and I may say it was the intention to put that in the permit. There were, however, clauses intended to force prompt and orderly development. We went on the theory that if we did that we could cut one of the roots of speculative monopoly, and could fairly expect that the States might help out by regulating prices and service.

Josiah T. Newcomb: I speak from the standpoint of public service companies that are interested in the development of water-powers primarily for use in public service. I think I can add something to the discussion in this matter by giving you some account of the present attitude of the water-power companies. The company that I represent professionally has under construction or in actual operation now some 285,000 horsepower of hydro-electric development. Its attitude prob-

ably has some bearing upon the attitude of the water-power companies in general. I don't believe very much in reminiscences. I was brought into this thing two years ago, and the very entertaining account Mr. Wells has just given is the first I ever knew of the preliminary difficulties that were involved in this subject. When I took hold of it two years ago I was furnished with briefs that the conservation charge was a tax, and furnished with briefs on the question of ownership of water, and was told there was a conference which took place, as Secretary Fisher said in my hearing in New York, when one of the representatives of a large power company, who was in a very critical mood, said: "Well, what of it? That is past and gone." The point of order on the fifty-year permit, that is past and gone. I don't suppose anybody understood the subject so well then as they do now.

I represent 285,000 horsepower now. In this work I have been brought into contact with the owners of probably one million horsepower. That is one-fifth of the developed horsepower in the United States. Persons properly accredited and representing that amount of developed power have all joined in submitting a proposed draft of a bill, submitted to the National Waterways Commission, which contains almost every one of the provisions contended for by the Government. The question of Federal control is no longer a question with the larger power companies. We realize it is a difficult problem for the Government to work out. If it is worked out in the form of State control, of course there has got to be cooperation, because wherever the ownership of water is, the State has court control over the use of water. There has got to be cooperation between the State and Federal governments. That is a problem for the Government to solve. We would rather be controlled by the Federal Government.

In conference in New York recently, when there was represented 750 million dollars, representing investments in public-service companies, electric lighting, etc., when this matter was up, one of the largest representatives there was speaking to me. I said, "There is no difficulty on that subject unless you want to contend for complete State control." He said he found himself in a complete minority on that and threw up his hands; that is the last I have heard about objection to a Federal policy of control. Ultimately it has got to come to a question of Federal control, because it will soon be a question of interstate business almost entirely.

Let us take up this question of compensation to the Government. That don't present any question of serious difficulty. The Government wants the principle of charging compensation for the use of the land estab-

lished. You own the land; you are certainly entitled to compensation for the use of it. What compensation do you want to charge? Admitting you want the principle, do you want to put on the principle of high compensation? If you put on an extremely high rate of compensation the companies cannot operate. The difference between generating power by steam and by water-power is not so great in cost. Assuming that you don't want to charge compensation that would result in no development, for in that case the cost of developing power by steam would be less than by water-power; and don't forget that the companies would prefer steam if the cost were the same, because we are in this business as investors. While we realize the argument that is made about the conservation of fuel, when it comes down to dollars and cents the investor is going to choose the best investment. In other words, the power that will make the best investment. Steam power is constant. Moreover, it does not depend on long transmission. It is far more dependable than electricity. You don't want to put the charge so high that it would throw us on a par with steam development, and then your fuel would not be conserved. Suppose the charge is below that. We are in a public-service business, furnishing light and power to the public. I am only stating now what is fully recognized by public officials. If you put your conservation charge at a high rate, and that high rate is transferred, as it certainly will be, to the consumer—assuming, of course, that you do not throw it up to the steam competition level—then you are simply putting so much more burden on the consumer. You don't want that. The Government, first, wants control, and, second, to reimburse itself for its outlay. It is in a certain sense immaterial to the public-service corporation what you do about that if you don't throw us into competition with steam.

It isn't necessary to discuss another phase of the subject. That phase is the electro-chemical industry, which can exist only if there is very cheap power. The difference of $1 per horsepower makes the difference between the absolute disappearance of a great industry in this country or its prosperity. In a conference on this subject a man was negotiating to take the surplus power from a plant for electro-chemical use, and they told him there would be a compensation of $1 per horsepower to the Government, and that he would have to pay it, and he began to figure that $1 charge as the whole basis of that industry. The Government must take that into consideration. It isn't so great a problem with the companies as with the Government itself.

Now, another matter—the compensation to the investor at the end of the period. If he is to make his investment for a number of years, and at the end of that time the plant is to be taken by the Government or be

transferred to some subsequent licensee, I think there should be some fair compensation to the investor at the end of the period, and that is fairly established. But, as Secretary Fisher said, there is great difficulty in determining just what property would be taken over by the Government or by the subsequent grantee. Now, I want to make a practical suggestion.

These transmission lines are not built for fun. They are to get power from the place of development to the market. Let us assume we have got a development 200 miles from a city. Is it conceivable that the Government would want to leave that city in darkness at any time? It is not at all conceivable. That transmission line is there just as firmly as the agencies of nature, furnishing light to the city from that distance. I don't know what can be imagined as happening in the future to interfere with that. Suppose, for argument, something did happen. What would you naturally take over? You would naturally take over the operation of that development, only excepting what was not necessary to light the city. You would take over the operation of the development down to the place where other power could be substituted for furnishing that market with the power that is required.

Now, in all human probability, whether this grantee continued or some other grantee came in, to furnish that power you would have to use the whole plant and transmission lines.

I appreciate that each of these questions will have to be decided by themselves. What does that lead to? As far as the companies are concerned, we will play any game you want us to play, but please tell us what the game is. In other words, let us through legislation—and this is what I have been trying to say—let us empower the Executive branch of the Federal Government, and let us stop there; empower the Executive branch to have full jurisdiction in handling the whole question. I don't think for a minute we can settle each case by legislation. Empower the Secretary of Interior and of Agriculture to handle each question with the companies.

I have assisted in drawing (after a pause)—I don't think I ought to say how many bills before Congress. There is not one of them which has not got page after page that really ought to come up only in the negotiations between the Federal Government and the investor. Of course, there is public sentiment to be taken into consideration. Some people are afraid the Federal Government will not get its rights, and they want to put everything in the bill. But give us an executive officer, or a board if you prefer, with whom we can deal, and who has authority to grant us

a suitable right upon which we can place our investment. If we like it we will take it; if not we will let it alone.

Water-power is interesting to people who know about water-powers. One of the worst jobs there is to perform is to get a man interested in water-power development who does not understand it. The first thing he does is to run to his lawyer, who tells him you can't get any rights, and the second thing he does is to run to an engineer, who says it is not a feasible project. At the head of one of the largest bonding houses is a man who will not touch a security that is based on water-power, because they were in some at one time that were not worth talking about. Give us somebody whom we can deal with and let us thresh it out in each case.

When there is a splendid market and the transmission is not too far, you can thresh it out mighty close with us; and where the market must be developed, and where we must have long transmission lines, we will thresh it out mighty close with you. If the Government is going into business it must do business as others do, and that is by trading.

Unlock the door and let us look the ground over. If we like the proposition let us be in a position to deal with some accredited Government official; if we don't like it we won't come in.

I have believed from the beginning there is just as much desire on the part of the conservationist to secure the development of water-power as there was on the part of the water-power company. Obviously, if you wish to conserve water you must get it developed as quickly as you can.

The practical result of all this discussion has been the standardizing of opinion. Now, Secretary Fisher gave a bang at the attorneys in this matter. He said he talked with one of the heads of a company, and he said he was all right if his attorney didn't tell him wrong. I had a conference in New York within ten days with one firm of attorneys, who advised the largest single water-power interest in the United States, in which the substance of the Burton Bill was discussed, and the attorneys in that case advised the reluctant vice-president of the company that that was a workable bill. (Applause.) On the same day I had a conference with a firm of attorneys in New York, who represent the largest water-power interests in Montana, and he said a bill along the lines of the Burton Bill would not only be acceptable for purposes of future development, but would probably correct a most difficult and serious situation which they already have on hand. I myself have devoted two years trying to drop a few seeds of education down here, but more particularly educating my clients. The attorney in Boston who represents a company which formerly got into difficulty with the Department over the terms of

lease has advised me that he considers bills along the lines just discussed absolutely satisfactory. There is a class of attorneys still that are advising their clients mistakenly, and I never knew where that original error started until now. Those people have written briefs and had discussions about the control of water, and I am not yet ready to render an opinion, although Mr. Wells has stated the California courts have decided against that, there is a well-formed opinion that the States have control of water. But anyhow you control the land and the water flows by it. Now, an eminent attorney in Minneapolis has given an excellent brief on that subject, one of the most profound discussions any of us have seen. It is a good bark, but he is barking up the wrong tree.

If you can get people to realize that that is not the question involved it will help in Congress. Nothing is so poor that it cannot be heard in Congress; also nothing is so poor that a wire can't be pulled for it in Congress, with all due respect to Congress and all branches of the Government. If we carry this matter to Congress, and make it realize that there is a standard of opinion on the matter, it won't be long before the question is settled.

FOREST TYPES: SYMPOSIUM

A STANDARD BASIS FOR CLASSIFICATION

BY S. T. DANA

Delivered before the Society January 23, 1913

In July, 1912, a tentative plan for a standard classification of land and forest types was suggested by the Forest Service for use on the National Forests. The main object of the proposed standardization was to secure uniformity in Service records by adopting a classification which would correlate, so far as possible, work done in the different districts and different branches. The classification was intended for practical use in connection with boundary, reconnaissance, timber sale, and all other work where a detailed, intensive classification requiring expert knowledge is not needed. For this purpose it must obviously be a comparatively simple one which can readily be applied in the field by the class of forest officers ordinarily assigned to such work.

The plan provided for three main divisions—"Treeless Land," "Woodland," and "Timberland." Treeless land was in turn subdivided into "Barren," "Desert," "Grass," "Cultivated," "Brush," "Sagebrush," and "Burn," while "Woodland" and "Timberland" were divided into forest types such as "Piñon-Juniper," "Western Yellow Pine," "Douglas Fir," "Engelmann Spruce," etc. The composition of the present stand was taken as the basis for the division into forest types, and stands with such marked differences in composition as to give them distinctive characteristics, were classed as separate types, irrespective of whether the type is a temporary or a permanent one. This basis was adopted for four principal reasons: (1) Because composition is the most natural and most generally used basis for describing forest stands; (2) because it is easier of practical application than any other; (3) because our forest management for many years to come will be concerned primarily with the present stand, and (4) because the present stand is generally a good indication of the site and of the climatic conditions prevailing in any given area. The plan went one step further than this, however, and in cases where the present type is clearly a temporary one, provided for indicating also the permanent type to which the area is evidently adapted.

Little criticism was made of the classification of "Treeless Land." The classification of forest types also met with fairly general approval, but in some quarters it was vigorously criticised, and in nearly all of the districts aroused considerable discussion. This discussion brought out so clearly the general haziness now surrounding the entire subject of forest types that this meeting was arranged to afford an opportunity to have all sides of the question clearly brought out and discussed.

The criticism of the proposed standardization is based mainly on two grounds: (1) That composition is not a proper criterion to use in distinguishing forest types, and (2) that any standardization of types is unwise, impractical, and unnecessary. It is these two points that I wish to take up particularly. Before going into them in detail, however, it may be well to call attention to the various ways in which types have been further subdivided, mainly according to their stability. Thus it is easy to find references in forest literature to temporary types, transitory types, transient types, transitional types, intermediate types, derivative types, timber types, dendrological types, cover types, permanent types, fundamental types, original types, mother types, natural types, physical types, natural physical types, final types, ultimate types, climax types, and management types.

Even worse than this multiplicity of terms is the fact that the same term is often used by different persons in an entirely different sense. Thus, by "natural type" one person may mean any type actually occurring in nature, while another may mean the type which will eventually take possession of any given area if nature is left to itself, and interference by man, fire, or other disturbing factors is eliminated. In the first sense, both western white pine and cedar-hemlock in northern Idaho are "natural types," while in the second sense western white pine is not a "natural type." A "physical type" may, according to the user, mean either the type which will eventually take possession of an area if all disturbing influences are kept out, or the type which we should strive to secure under forest management. In the first sense, to use the same illustration as before, cedar-hemlock would be a "physical type" and western white pine would not, while in the second sense western white pine would be a "physical" type and cedar-hemlock would not.

Illustrations of this sort as to the conflicting use of the same terms could be continued almost indefinitely. These, however, are sufficient to show the confusion which now exists and the necessity for some standard nomenclature. In order to avoid any misunderstanding as to what is meant when various types are referred to in this article, I wish to

define briefly the different kinds of types which it seems to me serve a useful purpose and should be recognized.

A *forest type*, known often as simply a *type*, is a stand of trees with distinctive characteristics of composition. A *cover type* is a forest type now occupying the ground. The term conveys no implication as to whether the type is temporary or permanent, or one which we shall strive to maintain under forest management. A *temporary type* is a forest type which has come in as a result of some interference with natural conditions, such as fire or lumbering, and which will eventually, if nature is left undisturbed, be replaced by a different type. A *permanent type*, or *natural type*, is a forest type which will eventually take possession of and perpetuate itself on any given area if natural conditions are undisturbed. A *management type* is a forest type that we shall strive to maintain under forest management, irrespective of whether or not it is the type that would occupy the area under natural conditions.

The definition of forest type just given has been objected to on the ground that the term *forest type* should be restricted to apply only to permanent types. The term has, however, been so generally used in the sense given in the definition that it has, I believe, become thoroughly established by good usage. Forest Service Bulletin 61, "Terms Used in Forestry and Logging," which was prepared in cooperation with this Society, defines a "Forest Type" as "a forest or a part of a forest possessing distinctive characteristics of composition or habit of growth," and draws no distinction between temporary and permanent types. Mr. Graves, in his "Principles of Handling Woodlands," defines a stand as "a general expression applied to any given portion of a forest having a distinct character." In accordance with these two definitions, a forest type is simply a stand in which the distinct character is its composition.

Perhaps much of the confusion on this point has arisen from a misinterpretation of Mr. Raphael Zon's article in Vol. I, No. 3, of the Proceedings of the Society of American Foresters, entitled "Principles Involved in Determining Forest Types." In this he says: "A natural forest type, then, is an aggregation of stands which may differ from each other in age, density, and other secondary features, but have the same physical conditions of situation, soil, topography, exposure, etc." This definition has sometimes been used as applying to any forest type. It should be noticed, however, that Mr. Zon was careful to use the qualifying adjective "natural." Mr. Zon himself, in the same article, recognizes that interference by man or accidents often bring about changes in the composition of a forest which must be reckoned with, and concludes that the resulting stands may be called temporary, transitory, or deriva-

tive types. Further, in an article entitled "Forest Types and Their Succession on the Kaniksu National Forest," delivered before the Botanical Society of Washington, December 10, 1911, he states that "a study of the forest revealed the existence of three main types, of which two are final, or climax, types and one a transitional type. The climax types are yellow pine-Douglas fir type and cedar-hemlock type. The transitional type is white pine-larch, which is the forerunner to the cedar-hemlock type."

The following quotations are from Forest Service Bulletin 79, "Life History of Lodgepole Burn Forests," by F. E. Clements: "The forest of Estes Park shows fairly well-defined types: (1) The yellow pine type; (2) the lodgepole-Douglas fir type, and (3) the Engelmann spruce-alpine fir type." "The greatest damage was done in the lodgepole type." "The vegetation which now covers the burned area consists of four different types, which repeatedly alternate. These are: (1) Pure stands of aspen; (2) mixtures of aspen and lodgepole; (3) pure lodgepole, and (4) mixed lodgepole and yellow pine." It is obvious that both temporary and permanent types are included in this classification, and to prove this still further, Professor Clements in the same bulletin states that "if fire were kept entirely out of the lodgepole areas in the central and southern parts of Colorado, these would disappear, to be replaced chiefly by forests of Engelmann spruce."

Such expressions as western white pine type, aspen type, and paper birch type, all applying to temporary forest types, are so common as not to require specific illustration.

The composition of any forest type, whether temporary or permanent, is determined both by the physical characteristics of the site and the silvical characteristics of the species. It has always been recognized that the physical factors, such as soil, moisture, temperature, and precipitation, have an important influence in determining the permanent or natural type. Mr. Zon, in his article in the Proceedings already alluded to, emphasizes these strongly, and pays very little attention to species, except to point out that composition is not a safe guide to use in distinguishing natural forest types. Yet it is true that the silvical characteristics of the species are almost equally important in determining the permanent type. Where the physical and climatic conditions are favorable for several species, as is frequently the case, the tolerance and reproductive capacity of the trees themselves determine what the permanent type will be. Intolerant species whose reproductive capacity is particularly vigorous, are often able to maintain themselves in a stand as individuals or as small groups, but if nature is left undisturbed it is

almost invariably the more tolerant species that constitute the final stand. Cedar and hemlock do not replace western white pine as the permanent type in northern Idaho and Douglas fir in the Northwest because they are better adapted to the physical conditions, but because they are more tolerant. This recognition of the part played by the trees themselves is important for the forester, since it means that the permanent type is not necessarily the one he will strive for.

On the other hand, the part which species play in determining temporary types has been emphasized and the part played by the physical conditions generally overlooked. Yet it is obvious that the physical conditions must be more or less favorable to the species composing the temporary type, or they would not come in at all. Thus, western white pine in northern Idaho follows fire as a temporary type in favorable situations at the lower elevations, but not at the higher altitudes and in inhospitable situations. Both temporary and permanent types, then, are determined primarily by physical conditions, which control tree distribution in general, and secondarily by the species, whose silvical characteristics determine which ones will finally win out in the struggle to secure possession of the area.

The practical importance of permanent forest types has, it seems to me, been rather over-emphasized. To quote once more from Mr. Zon's article in Vol. I of the Proceedings, he states that "in reproducing the cut-over forest, the forester must endeavor to obtain in the shortest possible time the original forest type, and since in the majority of our forests, as a result of cuttings made without regard to silvical requirements of the species, the original type is mostly supplanted by a temporary growth, the principal aim in caring for cut-over areas is to restore the original forest type." While this is perhaps generally true, there are many exceptions to it, particularly in humid regions. It is not infrequently the case that a type which would be temporary under natural conditions is more valuable for the forester to maintain than one which would be permanent. This is preëminently the case with Douglas fir on the Pacific coast and with western white pine in northern Idaho. In both cases the valuable Douglas fir and western white pine, which will naturally be favored in forest management, are replaced in the permanent type under natural conditions by the slower growing and less valuable western hemlock and western red cedar. Only those species should be favored, of course, which are adapted to the physical and climatic conditions of the locality; but when there are several species, all of which grow equally well, the forester will not and should not necessarily favor those which would eventually establish themselves in nature.

For the proper management of any given area there are two things which the forester must know: (1) What is at present on the ground, or the cover type, and (2) what should be grown there in the future, or the management type. The second point is obviously much the more difficult to determine, involving, as it does, a thorough knowledge of the physical conditions of the area, the silvical characteristics of the species, both in relation to their environment and to each other, and their commercial value. For this reason it will be necessary to go slow in attempting a management type classification until further investigations along these lines have been conducted. A cover type classification, on the other hand, being based merely on present composition, can safely be undertaken at once.

District 6 has gone particularly far in attempting to base its forest types on physical conditions and in ignoring composition. The reconnaissance instructions concerning these so-called "physical types" say: "The type classification should be based on physical features of environment, soil, altitude, climate, precipitation, etc.; not on the age or history of the stand, and not necessarily on its composition, although this usually is an indication of the type." And again, in commenting on the map showing "physical types," "This map shows the character of the ground or situation only."

The use of the term "physical type" in this sense is practically the same as the generally accepted meaning of "locality," or "site." This is defined in Forest Service Bulletin 61 as "An area, considered with reference to forest-producing power. The factors of the locality are the altitude, soil, slope, aspect, and other local conditions influencing forest growth. Locality class, or quality of locality, includes all localities with similar forest-producing power." Such a classification is undoubtedly a useful one for many purposes, but it would be better to drop the misleading term "type," and to substitute for it either of the approved terms "locality" or "site." In any event, it should be clearly understood that the term refers to the area and not directly to the stand.

The second objection to the proposed standardization of forest types is that it is impractical and unnecessary. In support of this contention it is argued that the same species has different characteristics in different parts of its range, and that it is inaccurate and unscientific to apply the same type name to stands of the same species in different parts of the country.

It is undoubtedly true that yellow pine stands, for instance, in Arizona and New Mexico are not precisely similar to yellow pine stands in eastern Oregon. Their general characteristics are, however, the same,

and it must be borne in mind that forest types are seldom discussed or made any practical use of except in connection with some particular locality, which at once calls up the peculiar characteristics of the type in that locality. Furthermore, there are minor variations in any given type even in the same locality. I venture to say that yellow pine stands in the Coconino National Forest in Arizona on limestone, malpais, and cinder soils differ nearly, if not quite, as much from each other as they do from yellow pine stands in Oregon, and that the yellow pine stands on the Whitman National Forest, in the Blue Mountains in eastern Oregon, differ as much from those on the east slope of the Cascades, in the Deschutes National Forest, as they do from those in the Southwest. It seems to me inconsistent, therefore, to group the Whitman and Deschutes yellow pine stands together merely because they happen to be in the same National Forest district, and to exclude the Coconino stands because they happen to be in a different district. Is there any good reason why they should not all be known as the "yellow pine type," recognizing, of course, the fact that the type is not absolutely uniform in all parts of its range? It is true that precisely the same method of cutting cannot be used in all parts of the same type; but this would be equally true under any classification whatever, since the exact trees to be removed must actually be selected on the ground in each particular case.

As far as the necessity for standardization is concerned, it is sufficient to point out that so many conflicting classifications are now in use that it is impossible for two persons holding different ideas on the subject to get together on any common ground without much fruitless preliminary discussion and argument.

Under present conditions, stands closely resembling each other in composition and general characteristics in the different districts may be variously designated as the Engelmann spruce type, alpine-fir type, Engelmann spruce-alpine fir type, upper slope type, sub-alpine type, and alpine type. Even on the same Forest different people by no means recognize the same forest types. Take, for example, the Kaniksu National Forest in northern Idaho, where the types have perhaps been studied as carefully as anywhere in the National Forests. Here Mr. Zon divides the forest into three main types—yellow pine-Douglas fir, cedar-hemlock, and white pine-larch. Prof. E. H. Shattuck, director of the Forest School at the University of Idaho, recognizes four types, two of which, yellow pine-red fir and hemlock-cedar, he describes as climax types, and two, white pine-larch and lodgepole pine, as transitional. F. I. Rockwell, on the other hand, divides the forest into six fundamental types—western yellow pine, pure Douglas fir, western larch-

Douglas fir, western white pine, Engelmann spruce, and sub-alpine. G. E. Tower recognizes a bull pine and red fir type, hemlock slope type, bottomland type, and alpine or ridge type; R. L. Fromme, a yellow pine type, lodgepole pine type, silver pine type, red fir slope type, and alpine fir type, and A. O. Benson, a white pine type, yellow pine type, Douglas fir type, temporary lodgepole type, alpine type, and barren type.

When such differences as these arise on a single Forest all sorts of inconsistencies and misunderstandings are obviously likely to occur in distinguishing types on different Forests and in different districts. Is it not clear that some standardization of forest types is not only desirable, but absolutely essential, to clear up this question and bring about some degree of uniformity?

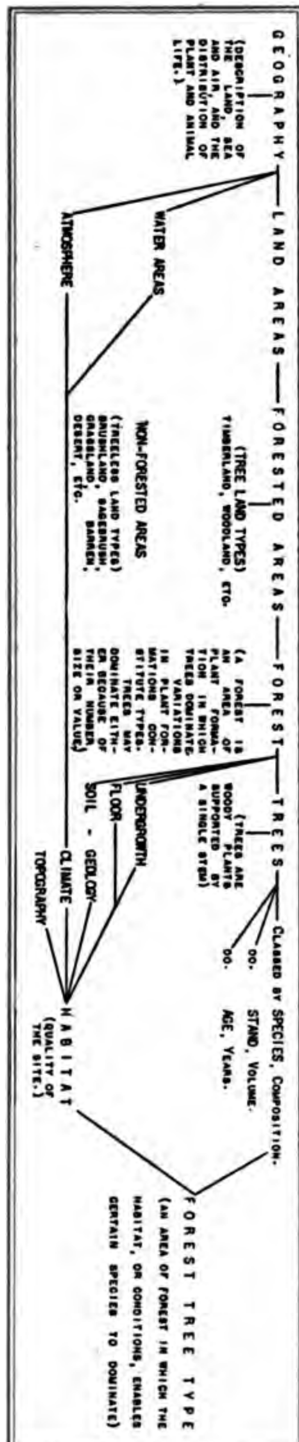
AN ANALYSIS AND SYNTHESIS OF THE TERM FROM A GEOGRAPHIC STANDPOINT

BY FRED G. PLUMMER

Delivered before the Society January 23, 1913

My contribution to the present discussion is submitted in diagrammatic form rather than text, since that seems the best means of expression.

Since a forest is an area of plant formation in which trees dominate, a type of variation of the formation should be recognized by the kinds of trees. Thus the composition of a forest determines the type to which, by the common consent of all practical foresters, it should be assigned.



FOREST TYPES · ANALYSIS AND SYNTHESIS OF THE TERM FROM A GEOGRAPHIC STANDPOINT

SHALL THE PHYSICAL CONDITIONS OR THE DENDROLOGICAL MIXTURE BE THE BASIS FOR FOREST TYPING?

BY THORNTON T. MUNGER

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Before entering into a discussion of the proper basis for distinguishing forest types it seems to me to be necessary to specify for what purposes forest typing is intended and to what degree of intensity the work is to be carried on. We all recognize that hardly any two acres of timberland, particularly in mountainous regions, are exactly similar either in composition or physical conditions. The painstaking student could make a separate type of nearly every acre of a small timbered tract which in its general features was uniform throughout; or if a very large region is being described, such as the United States, it might be divided into a dozen of what are called forest types, though more properly they are forest regions. Somewhere between these two extremes lies the kind of forest typing that it is practical for the forester to do and for him to use in the detailed administration of his tract on his working maps and in preparing his working plan. The so-called intensive reconnaissance, now in progress on many of the National Forests, demands typing of this nature. Its field-work consists in running cruising strips at least once, often twice, through every forty, making it practical to obtain a close estimate for each twenty or forty acre legal subdivision or compartment, and to indicate on the 4 inches to the mile maps any distinct variations in cover or type that extend over an area at least 10 chains wide. Let us assume, therefore, that the forest types discussed herein are of the intensity that it is practical to use in the so-called intensive reconnaissance work.

The term forest type must above all be used for a classification of timberland that will be useful to the practicing forester in forest management in a broad sense. Forest typing must not be merely a theoretic grouping of similar areas convenient for wall-map purposes or a classification of merely botanical or ecological interest. Their distinctions must be based on fundamental points of difference which have significance to the forester.

We all agree that forest typing consists in grouping timbered lands into a few or several arbitrarily defined classes, each of which is different

from every other class in certain respects and each of which is more or less homogeneous throughout. There are many ways in which we can divide up a timbered tract for purposes of classification. The classification may be made on the basis of the present stand, on the basis of the ultimate stand, on the basis of the amount of the stand in board feet, on the basis of the cutting period into which it falls, or on the basis of the climatic and soil factors of the site. Each of these classifications has its uses, and the forester may care to prepare maps of his tract showing graphically the distribution of any or all of them. The real question before us seems to be, Which of the systems of classification shall be called forest types?

In every form of intensive reconnaissance which a forester is doing preparatory to making working plans he should include the collection of data showing both the present composition by species and the physical conditions of the site. Though both of these classes of data may be shown on his maps, I feel that the term "forest type" should be reserved for a classification based upon permanent basic physical factors. I should define, therefore, a forest type as an aggregation of areas of forest land upon which the physical conditions of climate, soil, and moisture are so similar that an identical form of silvicultural management may be applied on all. Let me show just how such physical forest types would be distinguished and how they may be used.

If a working plan is to be prepared for a National Forest the forester wants to know how much land he has that is non-productive mountain tops; how much high, upper slope upon which only the slow growth of inferior species can be obtained; how much river bottom; how much foothill and highly productive lower slope country he has. Suppose that on this National Forest there occur six classes of sites or forest types. According to the plan which I favor, each would be given a name appropriate to its topographic situation or physical condition. The names used by some ecologists—Canadian, Transitional, and Hudsonian—have their merits, but are not adequate for the purposes of the forester. Names suggestive of the present or future composition of the forest are also to be avoided, since this classification is not based upon composition, and to name the types by their prevalent species would cause confusion. Each of these types would have certain definite characteristics of climate, soil, etc., and upon each similar forest management would be expected to produce similar results. So far as the silvicultural part of the working plan is concerned, each type would be considered as a unit and a single recommendation would apply to it. The burns, for example, would be reforested and handled in the way that was indicated for the physical

forest type to which they belonged. Growth studies would be made in each forest type, for each set of similar conditions may be expected to produce under management similar amounts of the desired kind of trees. Thus predictions of future yields could be made on the basis of the potential growing capacity of each forest type. Such a classification means something, for it is based on permanent factors; it is stable; it seems to me, therefore, the only true basis for a forester to use in working out the long-time management of his tract, and it is the only basis to which to apply normal yield tables. And the physical forest types being fundamental have many uses in timberland management beside silvicultural uses; they are convenient in forest description of all kinds and serve to define the site conditions on claims, special use areas, ranger stations, etc.

As many forest types may be distinguished as the variability of the physical factors and the intensity of the management require, in mountainous countries the variation will be greater than in plateau country. According to the definition and the degree of intensity described above, a whole township might fall in one forest type, or the type might change every quarter mile in a rugged region. In District 6 we find that nine forest types answer very satisfactorily for our intensive reconnaissance work in Oregon and Washington. Beginning on the western foothills of the Cascades and traversing them to their eastern foothills, the following types are used—their names are almost self-explanatory: Bottomland, Lower Slope, Upper Slope, Alpine (on both east and west sides of the divide), Transition, North Slope, Slope, Bench, and Lowland. While these types usually merge into one another gradually, consistent differentiation between them by reconnaissance parties is not difficult. Some of them are still further subdivided into two or three qualities—as, for example, the lower slope, which occupies a wide zonal belt on the west slope of the Cascades, and consists entirely of land adapted to pure stands of Douglas fir, manageable by the clean-cutting system, but which because of variations in depth and richness of soil has a variation in rate of growth which warrants its separation into Lower Slope—Quality I, Quality II, and Quality III. We could make as many more or twice as many more types, but nothing would be gained by complicating the typing beyond the point of practical application by the field force.

There is no doubt but that such a classification is useful to a forester. Besides being the basis for all his future plans, telling him just how much of each class of situations he has, it also tells him the areas that are adapted to each form of silviculture. This system of forest typing is also the basis for all agricultural land classification work, though for this

work the differentiation of the areas according to their physical factors will be carried a little farther than is necessary for forest management.

In the preceding paragraphs I have tried to show the advantages of making our forest types on the basis of their physical factors. Now, I want to indicate what seems to me to be the disadvantages of considering composition a primary basis for distinguishing types and to explain a more useful method of showing on reconnaissance maps the mixture of species.

It is, of course, very necessary for the forester to have a specific record of the composition of the forest on each unit of his tract, but I feel that that by no means necessitates classifying each piece of land according to the mixture that it chances to carry at the present time. A clear and useful method of showing the composition I will call attention to later. The mixture of species is an item in the estimate and has a bearing on the present timber-sale business. It is, moreover, in most forest regions an unstable condition and so haphazard that it cannot be considered the criterion by which to fix the future management of the tract. Let me illustrate: A tract on all of which the physical conditions are uniform and on which a half dozen kinds of trees occur may have fifteen distinct combinations of species, yet receive identical treatment in the hands of the forester. To divide up such a tract into several so-called types on the basis of its composition would be to adopt a form of typing that had no relation to the forester's handling of the tract. Such types would be dendrological, not forest, types. Reversely a single species may grow in pure stands in a variety of physical types; lodgepole pine, for example, grows both on the high Cascades, on the interior plateaus, and in the very humid sand-dune belt in District 6, as well as in other sites in other districts. To consider all these distinct physical types (*i. e.,* what I advocate calling forest types) as one because they produce pure stands of a single species would be misleading to the forester, because he wants to know where the physical conditions change that he may adapt his silviculture accordingly. Similarly no one would say that the pure stands of Douglas fir in Montana and the pure stands of Douglas fir in western Washington belonged to the same forest type, yet that is what forest typing by species would necessitate. Botanically they are the same, but from the forester's viewpoint they are so dissimilar in rate of growth and silvical requirements that they might as well be separate species.

The flora will often reflect the physical type, but forest-tree species alone are exceedingly treacherous indicators of the site, since some species grow under widely variable conditions, and since chance has played

such an important rôle in arranging the composition of the forests which we know as virgin.

As I have tried to show in the preceding paragraphs, my principal objection to classifying timberland according to composition and calling the classification forest typing is that it is wrong in principle. I also feel that it has practical objections. In a region where the species are many and the composition is variegated, it would be extremely hard in intensive reconnaissance work to type that area according to its composition, by running through a forty once, in a way that would be truthful and mean anything. Where species such as western yellow pine, Douglas fir, western larch, lodgepole pine, and white fir occur, each in pure stands and in a great variety of mixtures, as is usual, it would not be enough to have three or four broad classes when there actually are a dozen or fifteen distinct combinations. If the forester is basing his management on a classification by species the classification must be detailed to be useful: to adopt wide classes to cover a variety of mixtures is not scientific and is actually misleading. For example, if species are the criterion, terms such as the "white fir-larch" type or the "white fir-Douglas fir" type, where the inferior species may occupy anywhere from 25 to 75 per cent of the mixture, are too broad to be of any value, and are not the kind of classification that the forester can use. To make a distinct type for each dendrological mixture is in many regions absolutely impossible in actual practice. Frequently a forty will have a dozen patches of different combinations of species. To map all of these kaleidoscopic variations would necessitate unreasonably intensive field-work; not to map all would mean broad generalizations, showing really only forest-tree regions which would not be of practical use.

The forester should, however, have some way of showing the composition of the stand on each unit of his tract. The logical way to show this, I feel, is in exact figures as a part of the estimate, a special map being prepared on which the estimate by species for each forty is entered in ink. To my notion, it is much more useful to see directly on the map the exact figures for the number of board feet per acre of each species than to see that same compartment colored in a way to represent a certain mixture of species, the exact composition of which is not known. It is better to see on the map that the stand has 10,000 feet of yellow pine, 2,000 feet of Douglas fir, and 1,000 feet of white fir per acre than merely to see that it belongs to the "yellow pine-mixed species" type.

It has been suggested that what we are to call forest types be distinguished on the basis of the species that would ultimately occupy the ground if left to a state of nature—*i. e.*, the ultimate type or the climax

type. Such a classification, I think, is more logical than one made according to the temporary composition, but it would amount practically to a classification according to the physical conditions of the site *plus* a speculative factor as to the future mixture. To type land according to what ought to grow there if left to nature is a ticklish undertaking, liable in practice to lead to inconsistency and confusion or to relapse into a classification based merely on the physical factors. I think of two or three physical types of which silvical studies have been made, yet of which foresters are still in disagreement as to the ultimate cover type. Land that we call the upper-slope type has certain physical conditions, and under management will produce, we will say, 250 feet per acre per year of timber of various species of Abies, white pine, and mountain hemlock, but what the relative abundance of these trees will be we cannot tell very far ahead, nor for working plan purposes is it very important to know. Our silviculture will, of course, strive to evolve the most valuable mixture. If the land is typed, therefore, according to the physical conditions, it seems unnecessary to engage in fruitless speculation as to what species these physical factors will ultimately produce.

It has been suggested recently that a plan of standardizing the forest types of the country be inaugurated. Whichever way the forest land is classified, either according to differences in composition or in physical condition, the standardization should not be sweeping in its outlines. Generalization over large areas is extremely dangerous, for the differences that interest the forester in any one locality are local and specific. To amalgamate under one forest type-name somewhat similar areas in widely separated regions merely for the sake of standardization seems to me to be unwise. The timber-line forest type of the Cascades is not the same as the timber-line forest type of the Rockies or the Appalachians, and the lower slope and bench of each of the great mountain ranges have unique features. The mesas of Arizona are not the same as those of Oregon, though both grow pure stands of *Pinus ponderosa,* and from the forester's point of view the pine stands of one region are not the same as those of the other, though botanically identical. A dendrological type map might show these two regions in the same color, but on a forester's working map they must be separated. In order to secure a standardization throughout the country and at the same time preserve the distinctive local features of the classification in each district, I would suggest the following scheme: Establish a standard set of ten or fifteen type names, based on topography, such as those I have already referred to—bottomland, bench, lower slope, north slope, etc.—and in each distinct forest region of the country prefix to these physical types a local geo-

graphic title. For example, in Oregon and Washington we might call our forest types Cascade bottomland, Cascade lower slope, Cascade sub-alpine, while in California the same topography and relative situation, but a different climate, would make the Sierra bottomland, the Sierra lower slope, and the Sierra sub-alpine. In many instances a forest type, such as the Cascade lower slope, would be confined to a district; in other instances a type, such as the Rocky Mountain sub-alpine, might occur in two or three districts.

Such a scheme is comparable to that used by the Bureau of Soils, which divides all soils into several broad types according to their physical make-up—coarse sand, fine sand, sandy loam—and then names the soil of each of these broad types by some local name in accordance with its distinctive local characteristics.

Such a system of standardizing and naming the forest types of the country would be entirely feasible and would be actually very useful not only in all kinds of National Forest work, but to the foresters of the country in forest description and in scientific investigation. It would insure to each district a local scheme of types detailed enough for practical purposes, such as is needed in intensive reconnaissance work, and yet be so correlated to the scheme in neighboring districts that the advantages of consistency and homogeneity throughout the country would be attained.

USE OF FOREST TYPES IN THE WORK OF ACQUIRING LANDS UNDER THE WEEKS LAW

BY K. W. WOODWARD

Delivered before the Society January 23, 1913

In the examination of lands offered for purchase under the provisions of the Weeks law it has been found desirable to classify the kinds of forest stands and sites from two points of view. In the first place, it is necessary to know the composition of the present stands in order to arrive at the value of the timber. For this purpose the timber on a tract under consideration is divided up into stands of about the same composition, and for these an average stand per acre is determined. By this method a close approximation to the total stand on a tract can be determined, unless the tract is small and there is a great deal of variation in the stand. Obviously this method of estimating timber cannot be advantageously used on small tracts. In such cases it is necessary to cover the whole tract in order to be sure that all the good timber is included and that the thin stands are given proper weight. However, on large tracts where minor variations can be included in general averages this method gives sufficiently accurate results.

The second way in which sites need to be classified in valuing the lands offered under the Weeks law is to determine the value of the site for producing timber. In a virgin stand the present composition is a very good index of what can be grown on the area in question. However, it is conceivable that under forest management it may not be advisable to wait for the struggle of existence to proceed so far that temporary species are eliminated. For example, it may be found more advantageous to manage the upper slopes of the White Mountains so that stands of balsam may be secured rather than to wait for red spruce to come in. Obviously, therefore, it is necessary, in the valuation of the land for forest purposes, to hit upon some method of classification that will divide the different kinds of land according to their producing capacity. This producing capacity is dependent upon the climatic and soil factors. These, in turn, if left to themselves, will produce a stand of a relatively fixed composition, but the composition is merely a result of the climatic and soil factors.

As a means of classifying stands and sites, a system of types and subtypes is now in use. A forest type is understood to be an area in which

the climatic and soil factors are uniform and which may therefore produce stands of like composition. A subtype is a subdivision of a type in which the struggle for existence is not yet completed and whose composition is therefore changing. Generally this temporary condition is caused by fire, lumbering, windfall, etc. The most common species in subtypes are light-needing ones which occupy the ground quickly, but which will ultimately give place to more tolerant species..

The method of naming types and subtypes depends upon the features which are most prominent. On sites where the climatic and soil factors are of such a nature that one species is preëminently adapted to growth on that site, the type or subtype may be most conveniently designated by the name of the species. For example, in the White Mountains spruce is the species which is best adapted to the thin-soiled mountain slopes at high elevation. In the same way, on many of the ridges in the southern Appalachians chestnut oak is the species which is best adapted to such sites, and under natural conditions occupies the ground to the exclusion of other species.

On sites where the climatic and soil factors are so favorable that several species can contend successfully for the supremacy, the composition is not constant. For example, in the White Mountains the best spruce, as far as individual development is concerned, is found on the lower slopes. However, on these sites it never occurs in pure stands, because other species—notably the hardwoods, beech, birch, and maple—are able to contend successfully with spruce, white pine, and hemlock for root space and crown room. Hence, under natural conditions, a mixed stand of conifers and hardwoods is found on the lower slopes. The same conditions are found in the southern Appalachians. In the deep-soiled moist coves the composition varies greatly, even on the same tract. For example, on the north and east slopes hemlock has a tendency to occupy the coves to the exclusion of all other species. On warmer sites the coves are filled with yellow poplar, white oak, beech, sycamore, etc. The examples given above will show that it is impossible to always name the type by the most abundant species, if one wishes to class in the same group the sites which can be managed by the same methods. However, where climatic and soil factors only permit of one species growing successfully, the type can be most conveniently named by that successful species.

As a result, in the White Mountain region the two main types are the spruce and hardwood types. In the former are included the upper, relatively thinned-soiled mountain slopes, where spruce is able to drive out other competitors. In the hardwood type are included the lower

slopes, where the hardwoods, beech, birch, and maple, are generally most abundant, although any one species of hardwood may be less abundant numerically and in volume than some conifer, such as spruce, white pine, or hemlock. In the southern Appalachians, by reason of the great abundance of species and the mild climate, which enables a large number of species to contend successfully for occupation of the ground, the types cannot conveniently be designated by the name of the most abundant species. Therefore topographic designations are used. The main types are cove, slope, and ridge. Within these the composition varies a great deal, but each type is a unit of management. If found advisable the same species can be grown on all areas within the same type, since the climatic and soil factors are identical.

To illustrate the use of subtypes a few instances may be given. For example, in the White Mountains, after a burn within the spruce type paper birch, popple, and balsam are the first species to occupy the ground. After about 100 years, however, spruce forms a complete understory and takes possession, as the shorter-lived paper birch, popple, and balsam die. Such a condition would be designated as a burned subtype, or paper birch subtype, or balsam subtype of the spruce type. In this way the present condition of the stand may be indicated for purposes of estimating or management, and yet at the same time the future possibilities of the site are given. In like manner a cove may be occupied at the present time by a mixed stand of poplar, white oak, etc., or by pure stands of hemlock. Hence we may have a poplar subtype or hemlock subtype of the cove type. In this way the present stand is indicated, and yet it is known that this type may be used either for the production of hemlock or poplar, as seems best in the future.

In addition, the type classification enables us to determine the classes of land for which we are justified in paying different prices. To illustrate: The cove type is many times more valuable from the standpoint of timber production than the ridge type, simply because it will produce more timber in a given time and trees which will yield lumber of a better quality. This problem of determining soil values is one which is peculiar to our work, since it has never been necessary before in the work of the Forest Service to value timberland on a large scale for its capacity to produce lumber. In former valuations of timberland the values were based entirely upon the value of the standing timber and the possible use of the land for grazing or agriculture. It has been found, however, in the East that tracts which cannot be used for either grazing or agriculture, and which have no merchantable timber on them, have a real commercial value for timber-producing purposes.

The two ways in which the forest type classification are used in the work of the Branch of Acquisition illustrate the two uses to which forest types and subtypes may be put. In the first place, they may be used to designate the present composition. In addition, they find a growing use as a means of classifying the permanent climatic and soil factors which give different degrees of value to the soil of different tracts. The system of types and subtypes in use in our work permits of both temporary and permanent factors being given due consideration.

Likewise the varying conditions in the East illustrate the two methods of naming forest types. The members of the Service who are most thoroughly acquainted with the Rocky Mountain region naturally are in favor of naming types by the most prominent species. This does very well in regions where the climatic and soil factors are such that one species is preëminently adapted to a particular kind of site. However, in regions like the southern Appalachians and the Northwest, where the warm climate and abundant rainfall make it possible for a large number of species to contend successfully for supremacy, the composition within any virgin stand is not a sure index of like climatic and soil factors. Hence in these regions a topographic nomenclature seems more suitable. As long as the fundamental principle that forest types should be based upon what the site can be made to produce is kept in view, the system of nomenclature used matters little. The climatic and soil factors are the fundamental ones. The composition is merely the result of these factors.

DEFINITION AND USE OF FOREST TYPES

BY BARRINGTON MOORE

Delivered before the Society January 23, 1913

DEFINITION

The first point to settle is the definition of a forest type. A forest type is a tree society having such differences of composition from other tree societies as make necessary a separate study of its yield. It is similar to the plant society distinguished by ecologists, only broader. Furthermore, in practice the forester is often compelled to map several tree societies as a single type. This need not, however, cause confusion so long as he recognizes what he is doing.

ULTIMATE AND TEMPORARY TYPES

An ultimate forest type is that type which has been produced by physical factors, chief among which, so far as is known at present, are climate, aspect, chemical composition and physical texture of the soil and moisture, both in the soil and atmosphere, acting uninterruptedly over long periods of time.

Temporary types are the resultant of physical factors plus interference, such as fire, insects, heavy cutting, or any other agency which removes a considerable portion of the stand. Interference, if repeated at regular intervals, such as clear cutting at the end of a fixed rotation, exerts upon the stand, as long as it is continued, as much influence as any permanent physical factor. A temporary type is therefore a true forest type.

A subtype is a variation within a type. It is caused by minor differences in the physical factors which created the main type to which it belongs. In practice it is distinguished only in intensive work.

PHYSICAL FACTORS

Physical factors are, as Mr. Zon says in his well-known article on forest types in Vol. I, No. 3, of the Proceedings of the Society of American Foresters, the basis of forest types. This is pretty generally admitted. The important point, which seems to have been overlooked,

is that *physical factors are the cause of forest types; hence cannot be forest types in themselves.*

Classifying forest types according to physical factors creates confusion for two reasons: First, it is an attempt to classify something not by a characteristic inherent in the object itself, but by its causes; second, the physical factors causing forest types are so numerous, so complex, and so little understood, both in their nature and action, that to classify types by one factor about which a little is known and ignore others is absurd and misleading. This does not mean that it is incorrect to divide a forest into "bottomland, lower slope, upper slope," etc., for purposes of mapping and management. But these divisions are land classifications, not forest types. In District 6, where such a land classification has reached a high development, forest types, under the name of a "cover classification," are superimposed upon the land classification. In some cases the reverse may be desirable; for example, in Maine the spruce type may be divided into spruce slope, spruce flat, and spruce swamp.

The information most needed in the management (which includes reconnaissance, timber sales, silviculture, boundaries, and settlement) of any given piece of forest is that concerning physical factors. But these factors can only be determined by years of research at experiment stations—not by field observations, however careful. For the present, forest types furnish us a valuable index of these factors. The Bureau of Plant Industry, as Mr. Zon brings out in a memorandum, recognizes the great value of the vegetative cover as an index of the value of a soil. Why not use this index while the factors themselves are being studied, always, of course, watching for any indications of the underlying causes which may be observed in the field?

USE OF FOREST TYPES

Forest types are needed in boundary and settlement work, but more particularly in silvicultural management or the production of timber. The reason is that silvicultural management must be based upon studies of yield, and studies of yield must be based on forest types distinguished from each other by composition, subdivided, if need be, into site qualities. District 6 protests against the use of composition in determining forest types, yet you will notice that their yield study is based on Douglas fir, not on "bottomland." The criterion, then, of a forest type is whether or not it can be used in studies of yield.

The object of reconnaissance is to furnish the information needed in silvicultural management. To do this it must supply material to which

yield studies can be applied. Since yield studies are made by types, reconnaissance must divide the stand into types. Obviously those made in the yield study must correspond with those made on reconnaissance. For reconnaissance work the points of distinction between types must be simple, clear cut, and readily understood; fortunately in most forest regions composition satisfies this requirement.

SUMMARY

A forest type is a tree society having such differences of composition from other tree societies as make necessary a separate study of yield.

Physical factors are the cause of forest types, but not forest types themselves. They cause confusion when used in classifying forest types.

Yield studies are at the foundation of forest management, and must be based on forest types distinguished by composition.

Reconnaissance must furnish material to which yield studies can be applied. For this purpose it must distinguish forest types by composition, whatever other method is used in addition. Fortunately this is, for most regions, the easiest method of distinguishing forest types.

NOTE

Mr. Zon, in his article, "Quality Classes and Forest Types," uses the term "forest type" to indicate environment, or the sum of all physical factors; used in this sense, the "forest type" becomes synonymous with site quality.

The study and classification of physical factors has reached a high stage of development in Europe, particularly in Russia. Similar work is being done in this country as rapidly as opportunity permits. Foresters are agreed as to the necessity for it. The main point at issue becomes, therefore, one of terminology: Shall we call the environment or physical factors a "forest type," or shall we apply the term "forest type" only to the tree growth? It is evident that we require a separate term for each. Common usage in this country has generally made the term "forest type" apply to the forest cover. It would, therefore, simplify matters, I believe, if some other term such as "site" were recognized as applying to physical factors, while the term "forest type" is reserved for the forest cover.

CLASSIFICATION OF FOREST TYPES

BY W. B. GREELEY

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There have been three general stages in the work of the Forest Service, each involving a somewhat different point of view in the classification of forest types. The first was during the period when the National Forests were being selected and their boundaries defined. In that work we were concerned altogether with *forest cover* as distinct from other kinds of cover, and went no farther than the amount and composition of the stands which were actually found on the ground. The second stage is the administration of the National Forests. We are now interested in timberlands primarily from the standpoint of what they are producing and what they can be made to produce under scientific treatment. Our study and classification of forests is for the purpose of management, however specifically it may be expressed. We are now entering a third stage, which will be coincident in time with the second, but which I have designated separately because of the new problems and points of view which it involves. This is the development in our work marked by intensive studies of physical factors, soil, climate, water, topography, and the rest, for the purpose of classifying lands or in connection with the determination of yield and intensive silvical research. It is the stage, or rather phase, of our work in which the physical conditions making up the site become of primary importance in the study of forest lands.

During the first stage of the work of the Service the "cover type" in its simplest terms was adequate. In its second stage the "cover type" in itself is inadequate. We need rather the "management type." In the third phase of work to which I have alluded we need possibly an additional type—the "physical type" or "land type."

The bulk of our work now and in the future is in the second of the three general divisions which I have used. In this work, as I view it, the type needed for the classification and description of National Forest lands is the "management type." The classification of forested areas should, in my judgment, be attacked from the standpoint of what those areas will grow best under scientific administration. In other words, our study and description of forested lands should be in terms of what they will produce.

The best index to production under management is the existing stand. The possible production or the production to be sought under the management of an area can be gauged most accurately, in the broad, by past production.

My fundamental objection to the use of physical types in the classification of forest lands is that it confuses causes with effects. The things we are dealing with are effects—the grown or growing stands—and to my thinking our classification of forests should be based directly upon them rather than upon a complicated aggregate of underlying causes. In making this statement I do not disparage the study of physical factors, which is necessary in investigations of yield and the classification of agricultural lands, and which, of course, is involved in any adequate consideration of management. What we are seeking, however, is not an analysis of all the factors which must be taken into account by the silvical or working plan expert, but a simple, clear-cut basis for preliminary description in the field.

My belief in this matter is doubtless influenced by practical considerations. Out of 190 million acres in the National Forests less than 20 million have been covered by intensive reconnaissance. The completion of our reconnaissance, which is fundamental to intensive administration of any sort, is the greatest task in the field of forest classification now confronting the Service. Our basis of classification should be adapted to this work. The reconnaissance must be done for from three to five cents an acre; hence relatively inexperienced men must be employed upon it. These men are not competent to gauge accurately the physical factors making up a site. Their classification of the existing cover will be far more accurate and uniform, in my judgment, and will give the working-plan expert or technical administrator who uses their data a much more reliable basis to work with.

Our knowledge of the life history of types is constantly extending and becoming more accurate. Silvical studies are gradually revealing the whole story of the replacement of temporary types by permanent types, the effects of fire and other accidents upon the succession of types, and the like. If our reconnaissance crews simply report accurately the stands which they actually see, without trying to relate them to soil, moisture, and topography, our knowledge of the life history of types will enable us to interpret their data and apply it intelligently in management. I would, however, go farther than this. I would consider in our type classification not only what is now on the ground, but what should be on the ground under management. I would have the reconnaissance crews keep constantly in mind the forestry which should be

practiced on the lands which they are classifying and the possibilities of the stand under scientific handling.

Let us have, then, a classification of forest types based upon present cover interpreted where necessary by the uses which we will make of it in management. Let us leave the intensive study of physical factors to the working-plan expert or the silvicist.

The "management type," in my judgment, is the key to the classification of complex stands arising from changes in composition at different periods in the life history of the forest. In the stands of northern Idaho, where larch follows fire, white pine follows larch, and hemlock and other tolerant species follow white pine, with every conceivable gradation and mixture growing out of this rotation, I believe that our classification can be made clear and simple by selecting white pine as our "management type," the species which first and last is the best index of the type in all of its changing compositions, and which unquestionably we will utilize chiefly in management. In such stands I would classify all of the varying compositions as the "white pine type." I believe that similar simplicity can be secured on the west coast by classifying under the "management type" of Douglas fir the mixtures and combinations due to the natural sequence of species in those stands. I would apply this principle to any complex situation where a temporary type is followed by a permanent type, selecting for the purposes of our classification the stage in the natural rotation of species which, as far as we can now foresee, will be the basis of our forest management. In a word, the existing cover interpreter by our knowledge of the life history of the type and of what the land should produce under management will, I believe, furnish the best basis for systematic classification.

WHAT IS THE PROPER BASIS FOR THE CLASSIFICATION OF FOREST LAND INTO TYPES?

BY G. A. PEARSON

Contributed

In attempting to establish a basis for the division of forest land into types it is important to have a clear understanding of what constitutes a forest type. We have become so accustomed to using the term in a superficial sense, as applied to an area bearing a uniform species or composition of trees, that we are prone to lose sight of the fundamental elements of the forest type. For certain purposes it may be permissible to regard the forest type as merely an area characterized by a uniform stand; but in the scientific management of forests such a conception would lead to disastrous results.

The ultimate end in land classification in forestry is the determination of the potential producing capacity of different parts of the area involved. The fundamental elements in the forest type are, therefore, the natural site conditions, of which the stand of timber is but the effect of outward manifestation. A given forest may be regarded as the aggregate effect of the physical conditions obtaining on the land whereon it grows. If the physical conditions are uniform over the whole area, we may expect the forest to be uniform as to both composition and development, barring the intervention of outside agencies, such as the depredations of fire, disease, insects, and man; but any material change in these conditions will be expressed by a corresponding change in the forest.

The principal factors which determine the character of the forest are heat, light, and moisture, which in turn are modified by a number of indirect factors, such as altitude, topography, slope and aspect, wind, precipitation and atmospheric humidity, and soil, embodying both chemical and physical composition. Certain combinations of these factors will give a certain forest type, while other combinations will give a different forest type. By sufficiently exhaustive investigations it would be possible to ascertain within a definite range how much light, heat, and precipitation, making allowance for the influence of secondary factors, are required to produce a given type of forest on a given soil.

On the volcanic soils of the Coconino National Forest, at an elevation of 7,000 feet on level situations, where the mean annual temperature is

about 45 degrees F. and the annual precipitation about 24 inches, we usually have a forest of pure yellow pine (*Pinus ponderosa*). But on a steep south slope, where the sun's rays are more effective in warming the soil and air, and where, owing to increased temperature and exposure to the dry southwest winds, evaporation is increased, the yellow pine usually gives way to juniper and piñon. The same effect is brought about by a decrease in elevation, which in this region is accompanied by a decrease in precipitation, a rise in temperature, and a corresponding rise in evaporation. Similarly, on reaching elevations above 8,500 feet, particularly on northern exposures, we find that the yellow pine is being supplanted by Douglas fir, white fir, and limber pine. A record of climatic factors on such a site would show an increase of precipitation to 30 inches or more, a decrease in mean annual temperature to about 40 degrees F., and a corresponding decrease in evaporation. Returning to the yellow-pine type, we may pass abruptly from a typical stand of yellow pine to an area absolutely destitute of tree growth. Perhaps the origin of some of these openings may be traced to an ancient fire, but not infrequently the cause is to be found in the natural conditions of the site. Perhaps the soil contains an excess of salts or is of a physical condition unfavorable to tree growth. In places the soil is known to be underlaid by a stratum of hardpan, which resists the penetration of tree roots. Certain open areas are so situated that they receive the cold-air drainage from near-by mountains, with the result that frosts destroy seedling growth and may effectively resist invasion by the pine. The direct cause for the occurrence of such abrupt changes in vegetation is often difficult to ascertain. Sometimes it is to be found in a single factor and sometimes in a combination of factors; but it is certain that a cause does exist, and in most instances an investigation would prove this to be of natural character.

Having ascertained the conditions of soil and climate requisite for the various forest types in a region, it would be feasible to classify any new site, providing an accurate knowledge of the soil and climatic conditions on that site were available. This is perhaps the most scientific method of determining the producing capacity of sites, and where sufficient meteorological records exist it can be applied effectively; but where adequate meteorological records are not available it is impracticable for the use of the forester, excepting in detailed investigations and in the cases where simpler methods cannot be used. Furthermore, no findings based on mathematical data alone could be accepted as final until substantiated by an actual demonstration of what can be grown on the site under consideration.

Another method is to correlate species or plant associations with the physical conditions which produce them. If certain conditions are required to produce a certain plant association it is reasonable to assume that where that association occurs the corresponding conditions exist. This is the most common method of classifying forest land into types. Because of their long life-period, forest trees are especially valuable as indicators of site quality. If an area has borne to maturity and good development trees which are a century or more old, this is the best evidence that the area is adapted to the production of these trees; and knowing the requirements of the species, the trained observer can form a close estimate of the soil and climatic conditions prevailing. This principle is recognized in forestry to the extent that forest types are commonly designated by the names of the typical trees occurring on them. While this method appears very simple, its application calls for good judgment and a thorough knowledge of forest conditions. Although the mere fact that a species occurs on a given site is an indication of the presence of certain general physical conditions, a much more definite knowledge of these conditions is possible from a study of the habit and development of the species. Then there always arises the question of how far the presence or absence of a species is determined by natural or artificial factors. Fire, disease, insects, and man are powerful agents in changing the character of forests; but this effect is usually temporary, giving rise to what is known as temporary types.

Ultimately the retention or elimination of the great bulk of the lands within our National Forests will be decided largely upon the basis of their value for forestry as compared with agriculture, and therefore our classification must consider the capacity for producing agricultural crops as well as timber. Any such classification made at the present time will naturally be subject to more or less revision as the result of advancement in both forestry and agriculture, as well as changes in economic conditions; yet it is possible, if the knowledge now available is fully utilized, to establish a broad classification of permanent value. To accomplish this our land classifier must be qualified to judge the producing capacity of land with accuracy, and to this end a knowledge of local conditions as well as general principles is necessary. He must be able, first, to estimate the timber-producing capacity of each site upon the basis of past production and increased production possible from the application of advanced forestry, and, secondly, he must be able to correlate agricultural possibilities with the occurrence of tree species and other forms of vegetation, supplemented by available climatological data and such soil examinations as are possible.

Dr. C. Hart Merriam in his "Life Zones and Crop Zones of the United States," Bulletin No. 10, Biological Survey, divides the country into seven transcontinental belts or life zones and much larger number of minor areas or faunas, each characterized by particular associations of animals and plants. These zones and minor areas are found to correspond to natural crop belts, and are made the basis for an extensive and very practical study to determine the possible range of various agricultural crops. By correlating climate with the occurrence of typical native plants and animals, supplemented by the available climatological data, he has been able to construct a map showing the distribution of the different life zones, and also to indicate for different regions the species and varieties of agricultural crops which are likely to succeed there. It ought to be possible to make a very detailed study of this character on each of our National Forests.

Observations by the writer on the Coconino National Forest in Arizona serve to establish the following general relation between forest types and agricultural possibilities. Obviously the statements here given apply only to land which by topography and soil are suitable for farming, thus eliminating the rough and rocky lands which constitute the great bulk of the timbered types.

Engelmann Spruce type (Engelmann spruce and bristle cone pine; altitudinal range, 10,000 feet to timber-line).—No agriculture is practised in this type. The growing season is probably too short to mature even such crops as wheat, barley, and potatoes. Only a limited amount of land on the Coconino National Forest falls within this type, and all of it may be safely classed as non-agricultural.

Transition type (Douglas fir, white fir, limber pine, and yellow pine; altitudinal limits, 8,500 to 10,000 feet).—A very limited amount of farming is being carried on in this type, owing mainly to the small area of agricultural land available. The precipitation is abundant, but the growing season is short. Hay crops and early varieties of wheat, oats, barley, and potatoes ought to mature in ordinary seasons. The crops at present grown are chiefly grain-hay and a few vegetables.

Yellow Pine type (pure western yellow pine; altitudinal limits, 7,000 to 8,500 feet).—Wheat, oats, barley, speltz, and hardy vegetables, such as potatoes, onions, carrots, and cabbage, produce good crops. Excepting where irrigation is possible, the season is too short for many crops because of the limited rainfall during May and June. Timothy and alfalfa would doubtless succeed under irrigation. Even the hardiest fruits cannot be grown excepting in protected situations in the extreme lower limits of the type.

Woodland type (junipers and piñon; altitudinal limits, 5,500 to 7,000 feet).—The growing season is long enough to produce the common cereals, vegetables, and hardy fruits; but the precipitation is too low for farming, except under the most intensive methods. "Dry farming" is being tried out and promises to succeed. A great variety of crops could be grown under irrigation.

Desert.—This term is here used to cover all the treeless territory below the woodland type. Comparatively small areas of this type fall within the forest boundaries. Agriculture is generally not feasible excepting under irrigation. Where the land can be irrigated it is very productive, and is adapted to the common grains, alfalfa, and fruits.

The value of native vegetation as a criterion of the potential productivity of the land is not confined to trees; shrubs, herbs, and even the lower forms of plant life can often be used effectively. Bulletin No. 201, Bureau of Plant Industry, "Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area," by H. L. Shantz, furnished a good example of the possibilities in the way of correlating crop-producing qualities with the occurrence of different species and associations of grasses and other herbs. Dr. Shantz finds, for instance, that the occurrence of the gramma-buffalo grass association indicates a soil which though fertile is too compact to allow water, and consequently plant roots, to penetrate deeply, with the result that field crops grown on such lands are subject to drouth. The soil of the bunch grass association, on the other hand, though less fertile than that of the gramma-buffalo association, allows water as well as plant roots to penetrate deeply, with the result that crops grown on such lands are capable of withstanding severe drouth.

The above conclusions are confirmed by the writer's personal observations in Nebraska, Kansas, and Oklahoma. In south central Nebraska it is an established fact that in dry years, when crops fail on the fertile prairie lands, where buffalo and gramma grasses predominate, good crops are raised in the sand hills some 10 or 15 miles to the north, where bunch grass and bluestem are the predominant grasses. It is also a matter of common experience among the farmers in Nebraska, Kansas, and Oklahoma that in dry years the patches originally occupied by bluestem grass produce better crops than adjacent patches originally occupied by gramma grass or buffalo grass, while in wet years the relation is reversed.

Such studies as the one carried on by Dr. Shantz extended to our forest regions would be of inestimable value, not only as a means of establishing a working knowledge for land classification, but also as an aid in forest

management. It is readily conceivable how investigations of this character might explain the presence or absence of tree growth on different areas and decide beyond a doubt whether certain types of land should be used for forestry or agriculture.

In answer to the question of what is the proper basis for the classification of forest lands into types, the preceding discussion may be briefly summarized as follows: The only scientific basis for such a classification is that of potential productiveness, considering both agricultural and forest crops. The productive value may be ascertained in two ways: The first measures directly, as far as possible, all physical factors on the site and gauges the productive capacity by the measure in which the sum of these factors meets the requirements of various crops. The second method uses characteristic forms of vegetation on the ground as an indicator of the physical conditions present, and upon this basis ascertains the adaptability of the site for different crops. The obvious objection to the first method is the need of climatological data and soil analyses on each site to be classified; and, owing to the diversity of sites in our forest regions, together with the almost entire absence of climatological records in many sections, the collection of the needed data would involve an expense which, at this stage of our advancement in forestry, would be almost prohibitive. The second method requires a thorough preliminary investigation in each region to be covered, in order to secure a working knowledge for the actual land classification, and obviously reliable results can only be obtained by the employment of trained men. This method is the simpler and probably the more reliable of the two, and it is considered entirely applicable to the needs of the forester.

BASIS OF CLASSIFICATION INTO FOREST TYPES AND ITS APPLICATION TO DISTRICT 1

BY F. H. ROCKWELL

Contributed

Before discussing the different methods of classifying forest types it is necessary to agree upon definitions for the kinds of types under consideration. The following are referred to in this paper:

(1) *Temporary type*—a transitional condition, in which a forest of a temporary character is established as a result of some disaster which overwhelmed the original stand, but which will, if the disaster is not repeated, in time revert to the climax form.

(2) *Climax type*—named for the species which will eventually predominate as a result of physical factors concerned, provided the stand is left indefinitely undisturbed.

(3) *Cover type*—may be either temporary or permanent; in mature and overmature stands the name is based on the present composition; in immature stands it is based on the probable composition at maturity.

(4) A fundamental type which, similarly to the climax type, is based on physical factors of site, but named for the commonly occurring species most important from a management standpoint, instead of for the climax species. This will here be called, for want of a better name, the *"physical" type.*

A parallel list of the different kinds of types that are important in District 1 can probably best be used to illustrate the distinction between them:

Climax type	Physical type corresponding	Cover types occurring	Temporary types occurring
Western yellow pine	Western yellow pine	Western yellow pine	
Douglas fir	a Douglas fir	Douglas fir Western yellow pine Lodgepole pine	Western yellow pine Lodgepole pine
	b Western larch-Douglas fir	Lodgepole pine Western larch-Douglas fir Douglas fir Western larch Western yellow pine	Western larch Lodgepole pine Western yellow pine
Cedar-hemlock	Western white pine	Western white pine Douglas fir Lowland fir Western larch Western red cedar Western hemlock Lodgepole pine	Western white pine Douglas fir Western larch Lodgepole pine Possibly lowland fir
Lodgepole pine	Lodgepole pine	Lodgepole pine	
Alpine fir or Engelmann spruce	Engelmann spruce	Engelmann spruce Lodgepole pine Douglas fir	Lodgepole pine Douglas fir
Alpine fir Mountain hemlock Whitebark pine or Lyall larch	Subalpine	Alpine fir Mountain hemlock Engelmann spruce Whitebark pine Lyall larch	Occasionally Engelmann spruce Whitebark pine Lyall larch

The groups of "cover types" and "temporary types" are those which occur within the so-called "physical type" opposite which they are placed. It is seen that climax and our "physical" types are to a certain extent parallel, since physical conditions of site in both instances exert a controlling influence over the type. The "physical" types are more convenient to use than are the climax types, however, because the boundaries of the former may be drawn arbitrarily to include several climax types, or merely portions of one, as the objects of forest management may justify. Since the climax type, to be consistent, must be based on the climax species, however, the type limits there are drawn hard and fast by nature, and serve the purpose of management less readily. For example, take the "physical" Engelmann spruce type. This type comprises those moist-protected slopes and basins at high altitudes which naturally grow Engelmann spruce of good merchantable quality. The climax species in most instances is Alpine fir, and very frequently this

species largely predominates. Usually the presence of a few excellent specimens of spruce, however, indicates that it is the natural home of that species, and undoubtedly, especially in the region west of the Continental Divide, that is the species of greatest commercial value which can be grown there. By this system of classification, what is, strictly speaking, a portion of the climax Alpine fir type, which would usually be considered valuable only for protection purposes, becomes known as the Engelmann spruce "physical" type, very important from a timber-producing standpoint.

Another illustration of this principle is the division indicated above of the Douglas fir climax type into the Douglas fir and western larch-Douglas fir "physical" types. The distribution of western larch within the Douglas fir climax type is limited by its dislike of intense heat and severe droughts and by its deep-soil requirements to the moister, more favorable localities and sites of the type. Its southern and eastern limit is an irregular line from the Nezperce Forest diagonally across the Bitterroot and Missoula Forests to the point where the north line of the Missoula joins the Continental Divide, and thence north along the Divide into Glacier Park. There it crosses the Divide to the east slope. North and west of this line larch shares with Douglas fir practically all the better sites (the deep-soiled northerly slopes and flats) within the Douglas fir climax type, and also forms an important component of the western white pine forests. The more exposed slopes and shallow soils of the Douglas fir type are characterized by a total absence of larch, although, of course, there are all stages of gradation between the two on intermediate conditions of soil and aspect. The Douglas fir "physical" type is practically identical with the Douglas fir type of the Rocky Mountains, and is in reality an extension of the latter. These two "physical" types (or subtypes of the Douglas fir climax type) occupy probably 50 per cent of the forested area within the range of western larch in Montana, Idaho, and eastern Washington; in area one of them is probably as important as the other; from the standpoint of timber production the western larch-Douglas fir type is considerably the more productive of the two and yields the better quality of timber. Because of these facts, and because a recognition of the two types as distinct is practically equivalent to a broad-soil classification of the Douglas fir climax type, from a forest management standpoint their separation is certainly desirable.

To be consistent in our classification of climax types, the region known as subalpine should be subdivided in accordance with site characteristics into several types, depending on the species which would finally pre-

Climax type	Physical type corresponding	Cover types occurring	Temporary types occurring
Western yellow pine	Western yellow pine	Western yellow pine	
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	(b) Western larch-Douglas fir	Lodgepole pine Western larch-Douglas fir Douglas fir Western larch Western yellow pine	Western larch Lodgepole pine Western yellow pine
Cedar-hemlock	Western white pine	Western white pine Douglas fir Lowland fir Western larch Western red cedar Western hemlock Lodgepole pine	Western white pine Douglas fir Western larch Lodgepole pine Possibly lowland fir
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To be consistent in our classification of climax types, the region known as subalpine should be subdivided in accordance with site characteristics into several types, depending on the species which would finally pre-

dominate. On the Kaniksu, or on most of the Forests along the Continental Divide, the climax type would be whitebark pine for dry sites and Alpine fir for moist sites. On considerable parts of the Cœur d'Alene, Clearwater, and neighboring Forests, it would be mountain hemlock. For purposes of management, however, it is sufficient to group all high mountain types which do not produce timber of commercial value under the "physical" type name—subalpine.

For another example: In District 1 the site occupied by western red cedar, western larch, and western white pine are identical, the numerous variations in predominating species being due to the accident of seeding or to the age of the stand. Because of the greater importance of white pine from every standpoint, however, the advisability of calling the type western white pine instead of after the climax species, cedar-hemlock, is patent to all. Thus it becomes evident that our "physical" types should be preferred to climax types as a basis of type classification.

The list of types given above shows the occurrence of a considerable number of cover types in each of the "physical" types except western yellow pine and lodgepole pine, the cover types being arranged approximately in order of their importance, those occurring most widely and frequently being placed first. Several cover types are there mentioned which have not been included in the standard outline of cover types drawn up for the district, but which will nevertheless have to be included before reconnaissance is carried far on some of the Forests. This impossibility of reducing the system of cover type classification to final form is one of the great objections against it.

A glance at this list gives the impression that classification by cover types is more complicated and involved than by "physical" types, since the former appear to occur much more frequently. For the more humid portions of the district in which western white pine and western larch-Douglas fir types are found that is true. For the Rocky Mountain region proper, however, whether cover or "physical" types are considered, the types are very simple, being under either classification chiefly lodgepole pine and Douglas fir, with the subalpine, Engelmann spruce, and western yellow pine types occurring to a very limited extent. By far the greater portion of the region is covered by lodgepole pine, the species occupying not only its own type, but, through the aid of fires which have been prevalent from time immemorial, also very large, if not the larger, portions of the neighboring "physical" types, Douglas fir and Engelmann spruce. Here it is often quite difficult to tell what the true "physical" type is, and classification by cover types is the simpler.

West of the high main range of the Rockies, where the climate is more mild and relatively humid, the profusion of species makes the system of classification by cover types exceedingly difficult. While the cover types are controlled somewhat, between very broad limits, by site factors, their occurrence is largely due also to two other very important influences, viz., accident of seeding and age of stand. For that reason cover types only partially correspond to "physical" types. They are smaller in area, of great diversity in predominance of different species, and hence often confusing to identify in the field. Any use of site characteristics to aid in classification is an attempt to compromise "physical" with cover types, and only increases the confusion. The site characteristics indicative of definite "physical" types, however, while more or less local, are easily worked out for any given locality, readily recognized, and simple to map. From the standpoint of simplicity of operation in field work, therefore, in this region the use of the "physical" type has everything in its favor and is decidedly the more practicable. Undoubtedly the "physical" type could be almost as readily used in the Rocky Mountain region also, provided a close study of "physical" types was made for the locality, before beginning the reconnaissance project.

So much for the comparative ease of classifying by "physical" types and by cover types. Now let us consider the purposes of type classification and the method which will give us the most useful results.

The mapping of forest cover helps to answer questions chiefly concerning the present rotation. A knowledge of the stand on the ground is of assistance in estimating the future yield, especially if normal yield tables are to be used, and the future yield must be known before an intelligent limitation of annual cut can be established. A knowledge of cover conditions is also useful for various purposes of Forest administration, such as allotting grazing areas to permittees, laying out trails, and so forth. The greatest use of cover type maps, however, is in the promotion of timber sales, to show graphically the location of bodies of timber of different kinds.

Although a knowledge of forest cover is essential in the application of normal yield tables, only lodgepole stands are sufficiently pure or uniform over areas of considerable extent to enable the application of such intensive data. Even then, in the various "physical" types the yields are so different that a careful site classification and a yield table showing the yield of many different sites is necessary. A "physical" type map should answer the purpose of a broad site classification. With other species also the same thing is true, and in the case of those types where variable mixtures are more common, there is, with few exceptions,

markedly more difference in the yield of the same species in different "physical" types than there is in the yield of the different species or of different mixtures within any one type. For example, there is comparatively little difference between the yield of the two species, larch and Douglas fir, within the western white pine type or within the larch-Douglas fir type. The difference between the yield of either one of these species as it occurs in the two types is, however, very wide. For the types in District 1 other than lodgepole, the use of normal yield tables seems to be quite impracticable, and empirical yield tables based on the average for the entire type will be used. It is evident that with the great difference in the yield of a species in different "physical" types a classification of "physical" types rather than of cover types is needed. Where normal yield tables are to be applied, as in the case of lodgepole, some characteristic hatching or symbol to indicate the cover, if necessary, could be adopted.

A "physical" type map will not show in colors the predominance of different kinds of timber. Data showing the relative importance of the several species can readily be secured, however, and on our reconnaissance usually is, being expressed for mature timber by the estimates, for immature by the percentage of species in mixtures. These data can be placed in figures either on the "physical" type map or on the age class map, or, if desired, a separate map can be made. The information is not of permanent value, however; it will be useful only during the present rotation, which will, on most mature forests, end during the next decade or two. Data of permanent value are furnished by a "physical" typing, however, and a "physical" type map will nearly always be found of the greatest general use.

In addition to furnishing a better basis for the estimate of future yield and the regulation of annual cut, the knowledge of site conditions which a "physical" type map supplies is of great assistance in handling all the problems of forest management. After the types have been thoroughly studied we will know definitely the range of climatic conditions in each type—knowledge of great value in forestation, fire protection, and land classification work. We will know what species can grow in each type, their rate of growth, and what they will yield. We will know about the behavior of different species within the type, and can then plan intelligently the management of cutting operations, methods of brush disposal, and other problems of forest management. Not until the "physical" types are properly classified and mapped can these problems be definitely worked out.

PHYSICAL *VERSUS* COVER TYPES

BY D. T. MASON

Contributed

There are two classes of forest types, each of which has found its advocates in recent discussions in District 1. One of these types is based on physical factors, which will be called the "physical type." The other, based on the forest cover found on the area in question, will be called the "cover type." Unquestionably each type has its distinct points of advantage over the other. Since it is considered practicable, however, for men mapping in the field to show on their maps only one form of type, much argument has arisen as to which form should be shown. Men familiar with field mapping find that where the species are few, the cover types broad and distinct—as in the lodgepole region—the cover type is much the simpler to map, while in the white-pine region of northern Idaho, where many different species are found, there is a difference of opinion as to which form is the more easily recognized. When many additional data are available, it will probably be possible—and in most cases practicable—for highly intelligent men carefully trained to do the work to use either system in any region in District 1. It should be decided, then, which form of type is of the greatest use in forest administration, and that form should be used in field mapping.

A physical type map is principally valuable in forest management to indicate the species which can be grown most profitably on a given area. It is useful in case planting is to be done, or if a method of cutting merchantable timber is to be selected which will reproduce the proper species. A physical type map, then, shows the potentialities of the area mapped. It need show nothing with relation to the present forest cover, or even the presence or absence of forest growth. The cover type map, on the other hand, shows whether or not the area is timbered at all. It shows what kind of timber is now present on the area and its age. It indicates the nature of the crop which will be harvested during the present rotation.

The physical type map, then, shows what the land is capable of producing, while the cover type map shows what the land is producing. Which of these maps is most useful to the forest manager? First of all, he wants to know which portions of his unit are actually forested. For the forested area he wants to know the location of the different important timber species and whether the stand is of an age to render it suit-

able for cutting for various purposes. For each cover type he wants to know the age classes to determine where the over-mature timber in need of cutting is located; where the mature timber is to be found; where the immature timber in need of improvement thinning. In the lodgepole region, for instance, he wants to know where mature lodgepole can be found for mining stulls; where middle-aged lodgepole for converting poles; where dense young lodgepole in need of thinning for lagging poles; where Engelmann spruce can be found for flume lumber; where Douglas fir can be found for railway ties, saw-timber, etc. For purposes of regulation he also needs to know the percentage of the total area of each cover type at present in different age classes. These questions of primary importance in connection with the present rotation can be answered only by a map showing the cover types.

Some have proposed to include much of this information in physical type maps. Such action would simply result in a confusing hybrid. It is absurd to show an age class on a physical type map, for the combination of physical factors which such a map aims to show are not in the least affected by the age of the cover, if indeed there be any cover. It is only the cover which can have an age class which—if it is to be shown at all—should be shown on a cover type map. Frequently the cover actually found in a given physical type does not belong to that type. For example, where pure lodgepole pine occurs—as it very frequently does—on an area which the physical factors show to belong to the Douglas fir physical type, and the area is mapped as the Douglas fir physical type, it is ridiculous and misleading to ascribe to it the age of the existing lodgepole stand, for the age is a function of the lodgepole pine actually present, and is in no way connected with the Douglas fir, which nature, unaffected by fire, cutting, or other accident, would produce on the area.

If the cover type is important in connection with the present rotation, the physical type is important with relation to the next rotation. The physical type map indicates the species which may best be grown upon a particular area. This, however, is a matter of comparatively secondary importance in forest administration. Furthermore, questions as to proper species for planting and suitable methods of cutting are now solved by special studies rather than in the course of the work of the general reconnaissance crew. For instance, before cutting is undertaken on a large timber sale it is customary to mark sample areas, to draw up special marking rules, and where necessary to make a detailed marking map, the work being done by men especially qualified for it.

Such work is far too intensive to be handled by reconnaissance men working under present methods. Furthermore, it is work for which such men are usually unqualified. Similarly, before planting operations on a large scale are undertaken, a special study is made of the denuded areas available for planting work. If these special studies are to be continued as a preliminary to the regeneration of a given area, either by a special method of cutting or by artificial forestation, the principal objects of a physical type map will be attained without any work on the part of the reconnaissance crew.

Physical type maps are doubtless of great silvical and ecological interest, but cover type maps are more valuable at present to the men who are managing forests in a practical way.

PHYSICAL FACTORS AS A BASIS FOR DETERMINING FOREST TYPES

BY C. R. TILLOTSON

Contributed

Aggregations of plants of one or more species which grow on an area are termed plant formations or societies. These formations may be either temporary or permanent in character, the basis for such designation of course being determined by whether they occupy the area only for relatively short periods or for indefinitely long periods.

All areas in their beginning have been undoubtedly for a long period of years clothed with temporary formations of vegetation following one another in more or less rapid succession. These successions of different species and forms of plant life may be attributed to a number of causes. Important among these may be cited that of the changes in the habitat itself, largely in the character of its soil, which has been brought about through the influence of the preceding plant formations themselves. These new conditions permit or rather result in the invasion of species more suited to the changed habitat than those previously occupying it. Finally, however, it can be expected that one or more forms of vegetation of definite species will occupy the area and find it so exactly suited to their growth, development, and reproduction that they will be able to resist successfully all attempts at invasion by other species and will, barring unnatural changes in the habitat, retain their dominance in the formation indefinitely. In other words, a condition of stability in respect to the dominant vegetation on the area will have been reached which is the true criterion of a permanent formation. This is true not only of herbaceous growth, such as grasses and the annual and biennial small flowering plants, but also of woody growth such as bushes and forest trees.

To formations of forest trees the term type is generally applied, the predominating tree or trees in the stand in each case ordinarily designating the type, thus: Engelmann spruce type, lodgepole pine type, Alpine fir type, yellow pine-sugar pine type, etc.

Were all stands of forest trees growing under natural conditions which had been undisturbed by such agencies as fire, man, floods, or avalanches for a period amounting to that of a number of life cycles of the dominant species, it is quite possible that the types could be wisely and ap-

propriately designated by the use of the dominant species composing them, provided the differences within each so designated type itself due to climatic or other causes were in some manner indicated.

To any one familiar with species of trees that enjoy a wide range either latitudinally or longitudinally, or both, such as Douglas fir, western yellow pine, or Engelmann spruce, it is strikingly evident that the distinctive qualities of by far the greater proportion of forest types are largely regional. Thus, in speaking of the Douglas fir type, for instance, it is necessary before it can be clearly visualized to know first whether the type in question is that of the Pacific coast or of the Rocky Mountain regions; and further, if in the Rocky Mountain region, whether it is that of northern Idaho or of Colorado; and, second, whether the type is that of the north or south, east or west slope. Likewise, in speaking of the western yellow pine type, it would be necessary to state whether the type in question were, for instance, that of the east side of the Cascade Mountains or that of Arizona. Instances of this kind might be quoted extensively, but these will suffice to point out the idea. Stands even of the same species growing under quite widely different conditions will vary fully as much, and often more, than those of two different species growing under nearly similar conditions.

The factors considered most important by ecologists in the determination of the distribution and character of plant formations, or in the case of forest trees of forest types, are climatic, and may be briefly touched upon here. They are heat and moisture.

To quote disjointedly from Warming's "Œcology of Plants," the following statements are rather pertinent:

"Heat is to a far higher degree than is light an ecological and geographical factor not only in general but also in detail.

"Each of the various vital phenomena of plant life takes place only within definite (maximum and minimum) limits of temperature, and most actively at a certain (optimum) temperature.

"The upper and lower critical temperatures vary greatly in different species.

"To species both in respect of their conditions of life and their distribution, it is by no means without import which of the efficient temperatures (those between the maximum and minimum) prevail. The life of the individual is influenced not only by the height of the temperatures to which it is exposed, but also by the amount of efficient heat received or the duration of efficient temperatures. Annual mean temperatures are devoid of significance to plant life. Only the season during which useful temperatures prevail is of import. Thus, in northern Siberia, where the mean annual temperature is below —15° C., forests occur, yet on Kerguelen Island, where the mean temperature even of the coldest month is above freezing point, the vegetation is arctic.

"The temperature and length of the vegetative season affect the physiognomy of the individual plant and of the whole vegetation.

"The distribution and habitats of species in their main features (vegetative zones of the earth, vegetative regions of mountains) are determined by heat. In terrestial species of wide geographical distribution, the difference between the maximum and minimum temperatures is as a rule especially wide (this is not true of aquatic species). But above all, heat exerts an influence upon the habitat, economy, and struggles of plant communities."

Professor Mayr, in his "Fundamental Principles of Silviculture," makes the statement that to similar temperatures throughout the northern hemisphere similar species correspond.

To quote further from Warming:

"The ecological importance of water to the plant is fundamental and almost surpasses that of light or heat.

"It is not surprising that no other influence impresses its mark to such a degree upon the internal and external structures of the plant as does the amount of water present in the air and soil (or medium), and that no other influence calls forth such great and striking differences in the vegetation as do differences in the supply of water.

"A moist climate lengthens the life of individuals and of leaves.

"The geographical significance of water is still greater than that of heat because its distribution is still more uneven; this is true not only in the main but also and especially in details. Water is of all factors the most pregnant in relation to kind and distribution of plant communities.

"The relation between rainfall and the amount of water needed by the plant is of great import in regard to differences in the vegetation. Upon this depends the development of equatorial forest zones, where the rainfall is very great, of desert zones near the two tropics, where the rainfall is very scanty, and finally of the great temperate forest zones. The rainfall and its distribution during the seasons determine the great regional distribution of types of vegetation, while differences in the water capacity of the various kinds of soil and the various conditions controlling the course of water above ground determine *the finer topographical* shades of distinction.

"With the same rainfall, there is a very great difference accordingly as the rain falls uniformly throughout a long period or falls for only a very short time in the form of heavy storms; the number of rainy days is, in so far, therefore of greater import than is the amount of rain."

There are some other factors which are known to influence local or geographic distribution of species as well as their habits of growth, such as humidity of the air and soil composition. Chestnut, for instance, is said to avoid limestone soils, while the eastern red cedar finds such soils especially suited for its development. White pine in Ohio grows well on soils of granitic or sandstone formation, but only poorly on those derived from limestone. Professor Mayr claims that atmospheric humidity ap-

parently favors the formation of better and straighter boles in the pines and in all other species as well (*e. g.,* the increase of the straightness of the bole of pine from southwestern Germany to eastern Prussia and western Russia). It is, of course, also well known that wind may exert a considerable influence upon the habit of tree growth.

The influence of heat and moisture (particularly available soil moisture), however, are by far the most important factors which determine differences in plant growth and plant formations or more specifically to tree growth and tree formations. Except as they influence these two factors, topographic features are of no import.

The interrelation between heat and moisture is so close that it is somewhat difficult to separate the influence of the two, but because, as previously stated, the upper and lower critical temperatures vary greatly in different species it is safe to state that in the United States, where temperature conditions at the same altitudes are influenced in the main by differences in latitude, the latitudinal distribution of species is determined by temperature. Thus the northern limit of southern longleaf pine and the southern limit of white spruce are determined by the temperature condition prevailing at those limits. The influence of temperature on distribution is even so well recognized that the converse is also held to be true, that the temperature of a region is clearly manifested by the character of its flora. Thus the unearthing by paleobotanists of petrified remains of magnolias, liriodendrons, and sassafras in a section of Amethyst Mountain in Yellowstone Park gives eloquent support to the other proofs of former different climatic conditions in that region.

Within these latitudinal or temperature limits the distribution of species, as well as their habits of growth, are determined by moisture conditions, principally soil moisture. Compare the open stands of much-branched Douglas fir in the central Rocky Mountain region on the dry south slopes with that of the denser stands of much more clear-boled trees of the same species on the moist north slopes; also note the manner in which blue spruce follows the moist stream-courses, while further removed from the streams the Douglas fir occupies the area. The mangrove of the Florida coast, the cypress and gum of the swamps, still further illustrate the influence of moisture on distribution, in the case of the gum and cypress their occupation of the areas being due to the over-abundance of moisture preventing the growth of other species rather than to there being any actual necessity on the part of the gum and cypress for such a supply of moisture.

The water content of the soil at a critical period may determine the range of a species. Thus it is now contended and supported by Weather

Bureau records that the distribution of western yellow pine in Colorado is determined by the amount of snowfall during the winter months.*

All of the foregoing simply emphasizes the importance of the physical factors of climate in their relation to the distribution and character of plant formations in general and to formations of forest trees in particular, and points out the absolute necessity of the associating of forest types with climatic zones. While in the paper entitled "Forest Types," by Mr. Zon,† the influence of climatic factors was discussed at some length, still, through its being omitted from his definition of forest types in that paper, it was not given its proper significance. This definition should, therefore, it seems, be slightly amended to read as follows: "A natural forest type is an aggregation of stands *in the same climatic zone* which may differ from each other in age, density, and other secondary features, but have the same physical conditions of situation, like soil topography and exposure." This definition will necessarily preclude to a large extent the former practice of defining the types by species unless some means of correlating them with regions, and also designating them as permanent or temporary, are adopted.

The importance silviculturally of recognizing permanent forest types has been pointed out by Mr. Zon in its relations to the preparations of permanent working plans, and it is, of course, important to the Forest Service at present to a certain extent, even before the preparation of such complete working plans, in determining systems of marking in timber sales on the National Forests. That strict regard is or always should be given to securing the ultimate type in a region is open to some question. Is lodgepole pine, for instance, the ultimate type in the region where it forms practically pure stands over large areas, or is it simply a temporary type which, in the natural course of time, will be supplanted by Douglas fir at the lower elevations and by Engelmann spruce at the upper? If it is not the ultimate type, is it not even so, because of the facility with which it reproduces itself abundantly and its eminent adaptability for certain uses, the best species to maintain through silvicultural management on the areas where it is now growing so well?

Similarly is the Douglas fir the ultimate type on the good soils at the lower elevations in the Cascade Mountains where it occurs, usually the preponderant species at present, in mixture with the western hemlock, western red cedar, grand fir, and to some extent amabilis fir? Or is it predominant at present because of forest fires in the past and its well-known ability to stock and grow vigorously on burned-over areas? All

*Report "Silvical Aspects of Forest Planting," C. G. Bates.

†Vol. I, No. 3, Proceedings Society of American Foresters.

of its foregoing associates exceed it in tolerance, have greater ability to reproduce under dense shade, and it seems therefore that they would, under natural conditions, ultimately be predominant in the permanent forest types in such locations of this region. Because of its rapidity of growth, *par excellence* as a forest tree, and greater value for lumber than any of the other species mentioned, with the exception in the last respect of western red cedar, it will hardly be contended that it is not the most desirable tree to perpetuate on such areas, even if it would not naturally occupy them, barring such unnatural conditions as forest fires or the interference of man. The Forest Service, in fact, has recognized for some time that the Douglas fir is the most desirable species for such areas, and has created, through surface-burning of the slashings, unnatural conditions which are more favorable to Douglas fir reproduction than that of its associates mentioned.

Ordinarily it is undoubtedly true that better success will attend silvicultural operations if due regard be given to the establishment and maintenance of the permanent forest types. It therefore becomes important to learn to distinguish and to classify them. It seems that this will necessitate the division of a country into rather large areas, over which the same general conditions of temperature prevail at similar altitudes, these units to be subdivided into smaller areas, where similar conditions of precipitation both as to amount and distribution exist, and these still further into smaller units, where differences in exposure, topography, or soil exist. On similar areas of this last division the ultimate forest growth may be expected to be the same, both in composition and in character, and it makes little difference in speaking of the permanent types whether they are called, for instance, the north-slope type and the south-slope type, or the north slope Douglas fir type and the south slope Douglas fir type, providing the character of the growth in the region under discussion is known. The physical factors of the habitat will determine the type, and if these are known the character of the ultimate growth will be known by one familiar with the region. To one not familiar with the region any designation of types will in any case necessitate a description of them.

Where unnatural conditions have given rise to changes in the composition and character of forest growth, the ultimate nature of the type may be obscured and its determination may be facilitated by a study of the vegetation of the forest floor. Short-lived herbaceous and wood plants respond more rapidly to changes in habitat than do longer-lived species, such as trees, and a study of the former, the ultimate type of which may come in on an area and establish itself a considerable time before the ultimate type of forest prevails, will enable the prediction of the latter.

QUALITY CLASSES AND FOREST TYPES

BY RAPHAEL ZON

Contributed

There is often a tendency to consider quality classes and forest types synonymous. Whether quality classes will coincide with forest types or not depends on what is understood by forest type. If by forest type is meant only cover type, then quality classes must be a subdivision of the forest type, neither of which can be considered a safe guide for determining the productive capacity of the soil. If, however, by forest type is meant a silvicultural unit which has similar physical conditions of growth, then quality classes will naturally merge with forest types. In this paper the forest type is always taken in the latter sense. In central Europe, where forest management is confined to a few species and where the forests, like agricultural crops, are being grown over large areas, which include a variety of soils, the character of growth of the timber is the only expression of the productive capacity of the soils. In virgin forests, however, any difference in the physical factors affecting growth will express itself, not only in the character of the growth, but also in a different composition of the stand or undergrowth.

The average height of the timber is usually considered the measure of the site; the greater the average height of the stand of the same species the better is supposed to be the site or quality class. There are many instances of stands of the same species which, if classified in accordance with the average height, would be grouped in one quality class, yet form different types. Throughout the Medicine Bow region there are lodgepole-pine stands which unmistakably have arisen by crowding out the original stands of Douglas fir by the aid of repeated fires. In these lodgepole-pine stands there may be distinguished several site classes which correspond to similar site classes in the lodgepole-pine stands that occupy land which has always been occupied by this species. If lodgepole pine in the entire region was classified, therefore, according to the average height of the stands or site classes, into the same site class, there would be thrown together lodgepole-pine stands which grow on Douglas-fir situations and lodgepole-pine stands which grow on lodgepole-pine situations; in other words, stands belonging to different types. Such a classification for the immediate needs of reconnaissance or timber sales may be entirely

satisfactory. For the purpose of future management, however, the classification by the average height of the stand, irrespective of the forest type to which the stand may belong, will undoubtedly prove misleading. The management of the lodgepole pine growing on Douglas-fir situations must naturally be different from the management of lodgepole pine on lodgepole-pine situations. In the one case the aim should be to encourage the natural tendency of the Douglas fir to come in as natural reproduction, while in the other case such encouragement would be largely futile as it would be contrary to nature, because such stands can be managed only as pure lodgepole-pine stands. Instances of this kind are plentiful throughout the West and more so in the East.

Every classification is good as far as it serves the purpose for which it is made. If the aim is to secure an inventory of the standing timber, its composition, amount, and quality, it is evident that the basis for such broad classification must be the presence on the ground of commercial species—*i. e.,* composition of the stand—and for further subdivision the quality of the timber. If, however, the aim is to secure a natural classification as a basis for management, it must provide for such silvicultural divisions, units, or types as require distinct silvicultural treatment. Such silvicultural units are determined, not by the composition of the stand, not by the average height of the stand, but by the physical conditions of growth, such as climate, soil, drainage, and topography. Stands having the same physical conditions of growth will by necessity dictate eventually the same silvicultural treatment, irrespective of what the present composition or the average height of the stand may be.

Furthermore, site classes based on the average height of the trees are closely connected with the development of the stand from the very beginning. Two stands which on the basis of the average height of the trees must be considered as two distinct site classes, in reality would form one site class if the development was the same. One of the stands might have been burned over when young, or heavily grazed or overstocked or met with some other interference, while the other stand has had a more normal development, and therefore at maturity produced a better quality of timber, yet the physical conditions of growth are the same in both cases. To accept in such cases site classes and forest types as identical would be evidently misleading, as the former merely show what there is at present on the ground and not the productive capacity of the soil.

For these reasons one is forced to the following conclusions:

1. The division of a forest into stands having different average heights or site classes is perfectly justifiable as long as the end sought is purely an economic one.

2. An attempt, however, to use such site classes for forest types as an expression of the physical conditions of growth must necessarily lead to confusion.

3. Site classes based on the average height of the stand cannot always represent physical conditions of growth, as the same site classes may be found in stands which have entirely different physical conditions of growth; in other words, belong to two distinct forest types. Site class, therefore, while it indicates the actual character of the timber found on the ground, is not a silvicultural unit which can be used in management.

4. The average height of the stand or site class may be the result of the interference of man, fire, animals, etc., and for this reason cannot always be taken as the true measure of the productive capacity of the soil, even within the same type.

5. The classification of stands on the basis of their average height is still further deceptive, because it does not take into account the taper or the soundness of the timber, two qualities closely connected with the physical conditions of growth of the stand.

6. The use of quality classes alone as indicators of the physical conditions of growth is as misleading as to use the composition of the stand for defining forest types. Both at best show only the actual condition of the stand, but are entirely mute as to the physical factors that are the cause of it.

7. Since there are no characteristics within the stands themselves which could be used as unmistakable guides for dividing the forest into homogeneous silvicultural units and for acquiring exact knowledge of their silvical requirements, one must necessarily seek such characteristics outside of the stands.

8. Such guides are found in the external environment, with its climatic and soil peculiarities. These alone determine the composition and combination of the species as well as the silvical requirements of the stand.

9. It does not make any difference whether the name of the forest type is derived from the distinctive commercial species or topography, provided that in differentiating the forest into types the physical conditions of growth, which are the fundamental and primary causes of the real differences in the stands, are taken as the basis.

10. If forest types are based on physical conditions of growth they will necessarily determine also the character of growth and make superfluous the further subdivision into quality classes.

11. In a proper forest classification two things must be distinguished: (*a*) types of forest as the product of the physical conditions of growth,

and (*b*) the condition of the stands as the product of the interference of man or natural accidents. In the latter group will belong temporary types—sprout forests, abnormally open forests, the absence of undergrowth on account of grazing, etc. The classification into types is fundamental and is of importance not only for the present but also for the remote future. Classification on the basis of the secondary characteristics, which are merely stages in the evolution of the type, is important only for the immediate future.

12. A comprehensive classification of forests into types should begin by establishing, first, silvicultural units of various orders. The country as a whole should be divided into botanical-geographical regions—as, for instance, northern conifers, central hardwoods, etc.; each region must be subdivided further into subregions—thus the northern conifers into spruce subregion, pine subregion, etc. Within each subregion the forest should be divided on the basis of marked differences in topography and geology into types of forest massives. Each forest massive should then be divided into forest types, and within the boundaries of each type the stands may be further grouped by age, by origin, or by any other distinction which may be due to the interference of man or accident.

13. Without denying the importance of the secondary characteristics in describing and differentiating forest stands, these characteristics must be placed, it seems to me, in a different perspective—at the end and not at the beginning of the work. All attempts at forest classification so far made have been based either upon artificial characteristics or upon characters in which the interference of man was not separated from the natural factors. Such a classification inevitably included in one group stands extremely heterogeneous silviculturally. In order to secure a natural classification and at the same time a complete knowledge of the silvical requirements of the stand, it should embody in the classification both the natural characteristics and the characteristics produced by the interference of man, but subordinated the latter to the former—that is, the characteristics produced by man should be used for classification only within uniform conditions of growth—the physical conditions of growth for the same type must be so similar as to guarantee a biological uniformity of the stands.

One of the most urgent and fundamental silvical tasks of the present moment, in my opinion, is the working out of a natural classification of our forests. This must be the work of the very near future. Its difficulties are indisputable, but they are not insurmountable. Division of the forests into stands on the basis of their composition and average

height does not untie the difficult knot; it merely cuts it, and therefore does not solve the problem. The development of forestry in this country is rapidly getting away from the influence of Europe; we are constantly breaking new paths. A task which for natural historical reasons devolves particularly upon this country to perform is the working out of a natural classification of forest stands. This is our silvical mission, just as other countries have had their missions to perform.

PROGRAM OF MEETINGS

1912

January 11. Open Meeting. Methods of Forest Regulation Most Applicable to American Conditions. Barrington Moore.
Seed Production and How to Study It. (Discussion of article by R. Zon and C. R. Tillotson, published in Vol. VI, No. 2, of the Proceedings.) S. T. Dana.

February 1. Open Meeting. The Relation of Ground Cover to Erosion in the Southern Appalachians. Dr. A. C. Spencer.

February 15. Executive Meeting.

February 29. Open Meeting. Grazing in the National Forests. L. F. Kneipp.
Range Improvement and Improved Methods of Handling Stock in National Forests. J. T. Jardine.

March 21. Open Meeting. Silvicultural Systems for Western Yellow Pine. E. H. Clapp.

April 4. Open Meeting. Chestnut Blight and Its Control. S. B. Detwiler.

April 11. Open Meeting. Forest Planting in Florida. Bristow Adams.

April 18. Open Meeting. The Influence on Forestry of Economic Conditions which Control the Lumber Industry. Dr. C. A. Schenck.

April 25. Open Meeting. State Forest Problems in Maryland. F. W. Besley.

May 9. Executive Meeting.

May 23. Open Meeting. Regulation of Water Powers on National Forests. J. B. Adams, F. H. Newell, P. P. Wells, and J. H. Finney.

October 24. Open Meeting. Experimental Forest Planting in Hawaii. Ralph S. Hosmer.

November 21. Open Meeting. The Microscopic Structure of Woods in Relation to Their Properties and Uses. Eloise Gerry.

December 5. Open Meeting. Factors in the Valuation of Timber Lands in the Southern Appalachians. D. W. Adams and W. W. Ashe.

REPORT OF THE SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1912

Membership Roll

There were no elections to membership during the year, and there was no loss by death or resignation. In accordance with a resolution passed in the meeting of February 15 with regard to arrears in dues, the membership of the following has been terminated:

J. E. BARTON
WESLEY BRADFIELD
G. H. CECIL
G. B. LULL
H. G. MERRILL
A. B. PATTERSON
G. E. TOWER

The total membership of the Society on December 31, 1912, was 254, divided as follows:

Active	206
Associate	47*
Honorary	1
	254

The active membership may be classified as follows:

	Members	Per cent
Federal Forest Service	114	55
Other Federal bureaus	4	2
Government work in United States possessions and foreign countries	11	5
State work	19	9
Private and corporation employment	24	12
Teaching	34	17
	206	100

* Attention is called to an error in the Secretary's report for 1911, in which the number of associate members is given as 49. This number should have been 47, making the total membership of the Society at that time 261 instead of 263.

Geographically, the active membership is distributed as follows:

District of Columbia (and Maryland)		32
Northeastern States		
Maine	3	
New Hampshire	3	
Vermont	1	
Massachusetts	6	
Connecticut	9	
New York	11	
Pennsylvania	9	
New Jersey	2	
		44
Southeastern States		
North Carolina	2	
Georgia	1	
Florida	2	
Louisiana	1	
		6
Lake States		
Michigan	4	
Illinois	1	
Wisconsin	6	
Minnesota	5	
		16
Central States		
Iowa	1	
Arkansas	1	
South Dakota	2	
Kansas	1	
Oklahoma	1	
		6
Northern Rocky Mountains		
Montana	9	
Idaho	4	
		13
Central Rocky Mountains		
Colorado	9	
Utah	5	
		14
Southwestern States		
Arizona	4	
New Mexico	7	
		11
North Coast States		
Washington	9	
Oregon	15	
		24
California and Nevada		24

U. S. Possessions		
Philippine Islands	5	
Hawaii	1	
Alaska	1	
		7
Canada		7
Argentine Republic		2
		206

Sections

Two Sections of the Society have been organized, one at Missoula, Mont., with 11 active members, and one at St. Paul, with 14 members.

Publication of Proceedings

Two issues of the Proceedings—Vol. VII, Nos. 1 and 2—were printed and distributed during the year. Though no effort of any kind is made to advertise the Proceedings, more copies than ever have been sold outside of the Society, and the income from this source comprised 45 per cent of the entire revenue of the Society.

The mailing list has had 29 accessions during the year, and the Proceedings are now sent regularly to 249 addresses, exclusive of the active and honorary members (this includes 167 Forest Service field libraries).

There is no lack of material of a quality suitable for publication in the Proceedings; in fact the amount is sufficient to warrant publishing the Proceedings quarterly, provided a member could be found who could give the time to it. It is possible that some member connected with a forest school would be able to carry on this work to better advantage than a member connected with the Forest Service.

At the request of the Editorial Board, Barrington Moore has prepared a historical and critical review of all the papers which have appeared in the Proceedings. This review, which is entitled "Forestry in America as Reflected in the Proceedings of the Society of American Foresters," will probably appear in the May issue of the Forestry Quarterly. It is planned to secure reprints and distribute them with the next issue of the Proceedings.

E. H. Frothingham,
Secretary.

ANNUAL REPORT OF THE TREASURER

FEBRUARY 1, 1912, TO JANUARY 31, 1913

Receipts

Balance from previous year		$832.35
Annual dues	$500.00	
Sale of Proceedings	342.25	
Sale of stamps	.87	
Interest on bank deposit	16.30	
		859.42
		$1,691.77

Disbursements

Printing of Proceedings	$627.72	
Miscellaneous printing and stationery	185.53	
Stenography and typewriting	35.50	
Postage	50.34	
Express	1.30	
Telegraph	4.29	
Rent of Cosmos Club Hall	10.00	
Contribution to International Forest Bibliography	125.00	
Money order	1.40	
Account books	1.40	
		$1,042.48
Balance on hand		649.29
		$1,691.77

Assets

Cash on hand	$649.29	
Dues owed for 1911	18.00	
Dues owed for 1912	141.00	
Dues owed for 1913	615.00	
Owed for Proceedings	23.50	
Owed for reprint from Vol. VII, No. 2, of the Proceedings	25.00	
		$1,471.79

Liabilities

Printing—Byron S. Adams		2.50
Excess of assets over liabilities		$1,469.29

S. T. DANA,
Treasurer.

Audited and found correct.
BRISTOW ADAMS,
C. R. TILLOTSON,
Auditing Committee.

FEBRUARY 18, 1913.

MEMBERS

OF

THE SOCIETY OF AMERICAN FORESTERS

1913

ACTIVE MEMBERS

Date of election

ADAMS, BRISTOW, Forest Service, Washington, D. C. .... June 15, 1911
AKERMAN, ALFRED, Athens, Ga. .... April 2, 1903
ALLEN, RAYMOND WALTER, Forest Service, Cody, Wyo. .... June 15, 1911
ALLEN, SHIRLEY W., Forest Service, Red Bluff, Cal. .... Sept. 1, 1911
ALLISON, JOHN H., University Farm, St. Paul, Minn. .... Feb. 18, 1909
AMES, FRED ELIJAH, Forest Service, Portland, Ore. .... July 23, 1908
ASHE, WILLIAM WILLARD, Forest Service, Washington, D. C. ...... March 7, 1907
AYRES, PHILIP WHEELOCK, 6 Hancock Ave., Boston, Mass. .... March 7, 1907
BAKER, HUGH POTTER, N. Y. State School of Forestry, Syracuse Univ., Syracuse, N. Y. .... March 7, 1907
BAKER, J. FRED, Michigan Agric. College, East Lansing, Mich. .... Feb. 15, 1913
BALTHIS, RUSSELL F., Forest Service, Cloudcroft, N. M. .... June 15, 1911
BARD, GEORGE PHILIP, Forest Service, Pagosa Springs, Colo. ...... June 15, 1911
BARROWS, WILLIAM BURNET, Forest Service, Washington, D. C. ... June 15, 1911
BATES, CARLOS GLAZIER, Forest Service, Denver, Colo. .... March 24, 1910
BENEDICT, JUNIUS ST. JOHN, Gorham, N. H. .... Feb. 15, 1913
BERRY, SWIFT, Forest Service, San Francisco, Cal. .... Sept. 1, 1911
BESLEY, FRED WILSON, State Forester, Johns Hopkins Univ., Baltimore, Md. .... July 23, 1908
BILLARD, FREDERICK HOWELL, N. H. Timberland Owners' Assn., Berlin, N. H. .... Feb. 15, 1913
BRANIFF, EDWARD ANDREW, 616-618 R. A. Long Bldg., Kansas City, Mo. .... March 7, 1905
BRISTOL, HAROLD R., care Delaware & Hudson Co., Plattsburg, N. Y. .... Feb. 15, 1913
BROWN, NELSON COURTLANDT, N. Y. State School of Forestry, Syracuse Univ., Syracuse, N. Y. .... Feb. 15, 1913
BRUCE, DONALD, Forest Service, Missoula, Mont. .... Feb. 15, 1913
BRUINS, JOHN FRANKLIN, Forest Service, Pocatello, Idaho .... July 23, 1908
BRYANT, EDWARD SOHIER, 141 Milk St., Boston, Mass. .... Feb. 15, 1913
BRYANT, RALPH CLEMENT, Yale Forest School, New Haven, Conn. .. April 2, 1903
BUCK, CLARENCE JOHN, Forest Service, Portland, Ore. .... July 23, 1908
BURNS, FINDLEY, Forest Service, Washington, D. C. .... Feb. 18, 1909
BURRALL, HARRISON DEWITT, Forest Service, Porvenir, N. Mex. .... June 15, 1911
BUTLER, OVID MCOVAT, Forest Service, Ogden, Utah .... June 15, 1911

Date of election

CALKINS, HUGH G., Forest Service, Snowflake, Ariz..............June 15, 1911
CARTER, EDWARD EDGECOMBE, Harvard Forest School, Petersham, Mass. ....March 7, 1907
CARY, AUSTIN, Forest Service, Washington, D. C................March 2, 1905
CHAPMAN, HERMAN HAUPT, Yale Forest School, New Haven, Conn. ....March 7, 1905
CHEYNEY, EDWARD GHEEN, University Farm, St. Paul, Minn......May 21, 1908
CHITTENDEN, ALFRED KNIGHT, 607 E. White St., Champaign, Ill....April 2, 1903
CLAPP, EARLE H., Forest Service, Washington, D. C.............March 7, 1907
CLARK, ERNEST DWIGHT, Forest Service, Washington, D. C.......June 15, 1911
CLARK, ELIAS T., Forest School, Univ. of Washington, Seattle, Wash. ....June 15, 1911
CARK, JUDSON F., 403 Crown Bldg., Vancouver, B. C.............July 23, 1908
CLARK, WILLIAM DARROW, Mass. Agric. College, Amherst, Mass....Feb. 15, 1913
CLEMENT, GEORGE EDWARD, 275 Warren St., Boston, Mass.........April 2, 1903
CLIFFORD, EDWARD C., R. F. D. No. 1, Woodfords, Maine........March 24, 1910
COFFMAN, JOHN DANIEL, Forest Service, Weaverville, Cal.........Sept. 1, 1911
COHOON, ANSON E., Forest Service, Eugene, Ore.................April 28, 1909
COOK, ARTHUR MAYHEW, Forest Service, Fraser, Colo............June 15, 1911
COOK, HAROLD O., State Forester's Office, Boston, Mass...........Feb. 15, 1913
COOLIDGE, PHILIP TRIPP, N. Y. State School of Forestry, Wanakena, N. Y. ....June 15, 1911
COOPER, ALBERT WILLIAMS, Sec'y Western Pine Mfrs. Assn., Hutton Bldg., Spokane, Wash................................March 7, 1905
COX, CHESTER BOYD, Bureau of Forestry, Manila, P. I............Feb. 15, 1913
COX, WILLIAM THOMAS, State Forester, St. Paul, Minn..........March 1, 1906
CURRAN, HUGH MCCOLLUM, care Bailey Willis, Post Restante, Buenos Aires, Argentine Republic.........................March 7, 1905
DANA, SAMUEL TRASK, Forest Service, Washington, D. C........April 28, 1909
DETWILER, SAMUEL B., Chestnut Tree Blight Commission, 1112 Morris Bldg., Philadelphia, Pa...........................March 7, 1907
DRAKE, WILLARD M., Forest Service, Flagstaff, Ariz.............June 15, 1911
DU BOIS, COERT, Forest Service, San Francisco, Cal..............May 28, 1903
DUNLAP, FREDERICK, Forest Service, Madison, Wis................June 6, 1907
DUNSTON, CLARENCE E., Indian Office, Washington, D. C.........June 15, 1911
ELDREDGE, INMAN F., Forest Service, Pensacola, Fla.............June 15, 1911
ERICKSON, MARTIN LEWIS, Forest Service, Medford, Ore..........July 23, 1908
FERGUSON, JOHN ARDEN, Dept. of Forestry, State College, Pa.....June 15, 1911
FERNOW, BERNHARD EDUARD, Univ. of Toronto, Toronto, Canada...Dec. 15, 1900
FETHEROLF, JAMES MILTON, Forest Service, Ogden, Utah.........March 1, 1906
FILLEY, WALTER OWEN, Conn. Agric. Exp. Sta., New Haven, Conn..June 15, 1911
FISHER, RICHARD THORNTON, Harvard Forest School, Petersham, Mass. ....April 2, 1903
FLORY, CHARLES HENRY, Forest Service, Portland, Ore...........Feb. 15, 1913
FOLEY, JOHN, 413 Oak Lane, Wayne, Pa.........................Jan. 2, 1902
FOSTER, HAROLD DAY, Forest Service, Medford, Ore..............June 15, 1911
FOSTER, JOHN HAROLD, N. H. Agric. College, Durham, N. H.....March 24, 1910
FOXWORTHY, FRED W., Bureau of Science, Manila, P. I...........June 15, 1911

Date of election

FROMME, RUDO L., Forest Service, Olympia, Wash................Feb. 18, 1909
FROTHINGHAM, EARL HAZELTINE, Forest Service, Washington, D. C..July 23, 1908
GASKILL, ALFRED, State House. Trenton, N. J...................May 28, 1903
GAYLORD, FREDERICK ALAN, Conservation Commission, Albany, N. Y. ....June 15, 1911
GIFFORD, JOHN CLAYTON, Cocoanut Grove, Dade County, Fla......April 3, 1902
GOLDSMITH, BELKNAP CHITTENDEN, Forest Service, Alturas, Cal...Sept. 1, 1911
GRAFF, HERBERT, Forest Service, McCall, Idaho..................June 15, 1911
GRANGER, CHRISTOPHER M., Forest Service, Denver, Colo..........Feb. 15, 1913
GRAVES, HENRY SOLON, Forest Service, Washington, D. C.........Dec. 13, 1900
GREELEY, WILLIAM BUCKHART, Forest Service, Washington, D. C...Feb. 3, 1906
GRIFFITH, EDWARD MERRIAM, State Forester, Madison, Wis........Dec. 15, 1900
GUTHRIE, JOHN DENNETT, Forest Service, Springerville, Ariz.....March 7, 1907
HALE, HARRY MUNROE, Forest Service, Okanogan, Wash..........June 6, 1907
HALL, R. CLIFFORD, Forest Service, Washington, D. C............June 15, 1911
HALL, WILLIAM LOGAN, Forest Service, Washington, D. C.........Dec. 13, 1900
HAMMATT, RICHARD FOX, Forest Service, Sisson, Cal.............Sept. 1, 1911
HARRIS, PHILIP TALBOT, Forest Service, Tacoma, Wash...........Feb. 18, 1909
HATTON, JOHN HENRY, Forest Service, San Francisco, Cal.......March 2, 1905
HAWES, AUSTIN FOSTER, State Forester, Burlington, Vt..........March 2, 1905
HAWLEY, RALPH CHIPMAN, Yale Forest School, New Haven, Conn..Feb. 3, 1906
HILL, CARY LEROY, Forest Service, Northfork, Cal................June 6, 1907
HIRST, EDGAR CLARKSON, State Forester, Concord, N. H..........June 15, 1911
HODGE, WILLIAM CHURCHILL, JR., Forest Service, San Francisco, Cal...April 2, 1903
HODSON, ELMER REED, Forest Service, Ogden, Utah..............March 7, 1907
HOLMES, JOHN SIMCOX, Chapel Hill, N. C.........................June 6, 1907
HOSMER, RALPH SHELDON, Box 207, Honolulu, Hawaii............Dec. 13, 1900
HOWARD, WILLIAM G., Conservation Commission, Albany, N. Y....June 15, 1911
IMES, RICHARD PERRY, Forest Service, Custer, S. Dak...........March 7, 1907
JACKSON, ALEXANDER GRANT, Forest Service, Seattle, Wash.......Feb. 15, 1913
JUDD, CHARLES SHELDON, Forest Service, Portland, Ore........March 24, 1910
KEACH, JOHN E., Forest Service, Avery, Idaho...................June 6, 1907
KELLETER, PAUL DELMAR, Forest Service, Deadwood, S. Dak......Feb. 18, 1909
KELLOGG, FRANK B., 98 El Camino Real, Berkeley, Cal...........Feb. 15, 1913
KELLOGG, ROYAL SHAW, 506 Third St., Wausau, Wis.............March 7, 1905
KEMPFER, WILLIAM HERBERT, Forest Service, Madison, Wis.......Feb. 15, 1913
KENT, WILLIAM H. B., Bureau of Forestry, Manila, P. I.........April 28, 1909
KIEFER, FRANCIS, Forest Service, Harrison, Ark.................June 15, 1911
KINNEY, DAVID GOLDEN, Forest Service, San Diego, Cal..........July 23, 1908
KINNEY, JAY P., Indian Office, Washington, D. C................Feb. 15, 1913
KIRKLAND, BURT P., Dept. of Forestry, Univ. of Washington, Seattle, Wash. ....Feb. 18, 1909
KLEMME, WILHELM, Bureau of Forestry, Manila, P. I...........April 28, 1909
KNECHTEL, ABRAHAM, Box 1133, Grandon, Manitoba, Canada....March 1, 1906
KOCH, ELERS, Forest Service, Missoula, Mont...................March 7, 1905
KÜMMEL, JULIUS F., Forest Service, Portland, Ore............March 24, 1910
KUPFER, CARL ALBERT, Forest Service, San Francisco, Cal........June 15, 1911

Date of election

LAFON, JOHN, JR., care Minister of Lands, Victoria, B. C.........Feb. 15, 1913
LEAVITT, CLYDE, care Conservation Commission, Ottawa, Canada..July 23, 1908
LEOPOLD, ALDO, Forest Service, Tres Piedras, N. M...............Feb. 15, 1913
LOVEJOY, PARISH S., 1820 Hill St., Ann Arbor, Mich.............June 15, 1911
LYFORD, CHARLES A., 206 Board of Trade Bldg., Montreal, Canada..Feb. 3, 1906
MACDONALD, GILMORE B., Iowa Exp. Station, Ames, Iowa........June 15, 1911
MACDUFF, NELSON FERRIS, Forest Service, Grants Pass, Ore......June 15, 1911
MACKAYE, BENTON, Forest Service, Washington, D. C............June 15, 1911
MCLEAN, FORMAN T., Forest Service, Ogden, Utah...............June 15, 1911
MADDOX, RUFUS SHERRELL, Forest Service, Quincy, Cal............Sept. 1, 1911
MARGOLIN, LOUIS, Forest Service, San Francisco, Cal.............Feb. 3, 1906
MARSTON, ROY LEON, Skowhegan, Maine.......................May 28, 1903
MASON, DAVID TOWNSEND, Forest Service, Missoula, Mont......March 24, 1910
MAST, WILLIAM HERBERT, Davenport, Iowa.....................July 23, 1908
MATHEWS, DONALD M., Bureau of Forestry, Manila, P. I..........Feb. 15, 1913
MATTOON, WILBUR REED, Forest Service, Washington, D. C......March 1, 1906
MAULE, W. M., Forest Service, Gardnerville, Nev................Feb. 18, 1909
MELL, CLAYTON DISSINGER, Forest Service, Washington, D. C......June 6, 1907
MERRITT, MELVIN L., Forest Service, Bend, Ore..................Feb. 15, 1913
MILLAR, WILLIS N., Box 1253, Calgary, Alberta, Canada..........Sept. 1, 1911
MILLER, FRANCIS GARNER, Wenatchee, Wash....................March 5, 1904
MITCHELL, JOHN ALFRED, Forest Service, San Francisco, Cal......Sept. 1, 1911
MOODY, FRANK BENJAMIN, School of Agriculture, University of Wisconsin, Madison, Wis.................................Feb. 18, 1909
MOON, FRANK F., N. Y. State College of Forestry, Syracuse Univ., Syracuse, N. Y...June 15, 1911
MOORE, BARRINGTON, Forest Service, Washington, D. C...........June 15, 1911
MOORE, SYDNEY LUARD, 911 National Bldg., Savannah, Ga........May 21, 1908
MOORE, WALTER MORRISON, Forest Service, Santa Barbara, Cal....June 15, 1911
MORRELL, FRED W., Forest Service, Denver, Colo.................July 23, 1908
MULFORD, WALTER, College of Agric., Cornell Univ., Ithaca, N. Y..March 5, 1904
MUNGER, THORNTON TAFT, Forest Service, Portland, Ore........March 24, 1910
MURDOCH, JOHN, JR., 11 Claflin Place, Newtonville, Mass.........June 15, 1911
MURPHY, LOUIS SUTLIFFE, Forest Service, Washington, D. C....March 24, 1910
NEEL, HARRY CAMBLE, Dravosburg, Pa.........................July 23, 1908
NELSON, JOHN MARBURG, JR., P. & R. C. & I. Co., Pottsville, Pa....June 6, 1907
OLMSTED, FREDERICK ERSKINE, 21 Lime St., Boston, Mass.........Dec. 15, 1900
OMAN, ANDREW EDWARD, Forest Service, Weiser, Idaho...........May 21, 1908
PEARSON, GUSTAF ADOLPH, Forest Service, Flagstaff, Ariz.......March 24, 1910
PEAVY, GEORGE WILCOX, Oregon Agric. College, Corvallis, Ore....March 1, 1906
PECK, ALLEN STEELE, Forest Service, Albuquerque, N. M..........June 6, 1907
PETERS, JAMES GIRVIN, Forest Service, Washington, D. C........March 7, 1905
PETTIS, CLIFFORD ROBERT, Conservation Commission, Albany, N. Y..July 23, 1908
PINCHOT, GIFFORD, 1615 Rhode Island Ave., Washington, D. C.....Dec. 13, 1900
PIPER, WILLIAM BRIDGE, Forest Service, East Tawas, Mich.......June 15, 1911
PLUMMER, FRED GORDON, Forest Service, Washington, D. C.......July 23, 1908
POTTER, ALBERT F., Forest Service, Washington, D. C............June 15, 1911
PRATT, MERRITT BERRY, Forest Service, Nevada City, Cal.........July 23, 1908

Date of election

PRESTON, JOHN F., Forest Service, Missoula, Mont..............June 15, 1911
PRICE, OVERTON WESTFELDT, Colorado Bldg., Washington, D. C.....Dec. 13, 1900
RAMSKILL, JEROME HINDS, Forest Service, Delta, Colo...........June 15, 1911
READ, ARTHUR DAVIS, Forest Service, Albuquerque, N. M.........Feb. 18, 1909
RECKNAGEL, ARTHUR BERNARD, College of Agric., Cornell Univ., Ithaca, N. Y..May 21, 1908
REDINGTON, PAUL G., Forest Service, Northfork, Cal..............Feb. 3, 1906
REED, FRANKLIN WELD, Forest Service, Washington, D. C........March 5, 1904
REYNOLDS, ROBERT RENSSELAER, Forest Service, Ogden, Utah.....June 15, 1911
RILEY, SMITH, Forest Service, Denver, Colo....................March 2, 1905
RINGLAND, ARTHUR CUMING, Forest Service, Albuquerque, N. M...July 23, 1908
ROCKWELL, FRANK I., Forest Service, Missoula, Mont.............Sept. 1, 1911
ROGERS, DAVID NATHAN, Forest Service, Quincy, Cal..............Sept. 1, 1911
ROGERS, ROBERT LANSING, Forest Service, Washington, D. C.......June 15, 1911
ROTH, FILIBERT, Univ. of Michigan, Ann Arbor, Mich.............Dec. 15, 1900
ROTHERY, JULIAN EASTMAN, 527 Fifth Ave., New York, N. Y......June 15, 1911
ROTHKUGEL, MAX, Florida 524, Oficina de bosques, Buenos Aires, Argentine Republic ....July 23, 1908
SACKETT, HOMER S., 1211 Whitney-Central Bldg., New Orleans, La. June 15, 1911
SCHENCK, CARL ALWIN, Biltmore, N. C..........................Dec. 15, 1900
SCHWARZ, GEORGE FREDERICK, 1223 Beacon St., Brookline, Mass....Jan. 2, 1902
SCOTT, CHARLES A., Agricultural College, Manhattan, Kans......March 1, 1906
SHEPARD, WILLIAM CHAMBERS, R. F. D. 59, Berlin, Conn..........June 15, 1911
SHERFESEE, WILLIAM FORSYTHE, Bureau of Forestry, Manila, P. I..March 7, 1907
SHERRARD, THOMAS HERRICK, Forest Service, Portland, Ore.......Dec. 13, 1900
SHINN, CHARLES HOWARD, Forest Service, Northfork, Cal........March 7, 1907
SIECKE, ERIC OTTO, Deputy State Forester, Salem, Ore...........July 23, 1908
SILCOX, FERDINAND AUGUSTUS, Forest Service, Missoula, Mont.....June 6, 1907
SKEELS, DORR, Forest Service, Libby, Mont......................Sept. 1, 1911
SMITH, CHARLES STOWELL, Forest Service, San Francisco, Cal...March 24, 1910
SMITH, CLINTON GOLD, Forest Service, Logan, Utah..............Feb. 18, 1909
SMITH, STANTON G., Forest Service, Seattle, Wash...............Feb. 18, 1909
SPONSLER, OLENUS LEE, Univ. of Michigan, Ann Arbor, Mich......June 15, 1911
SPRING, SAMUEL NEWTON, College of Agriculture, Cornell Univ., Ithaca, N. Y...March 5, 1904
STABLER, HERBERT OSBURN, Forest Service, Portland, Ore.........July 23, 1908
STEPHEN JOHN WALLACE, N. Y. State School of Forestry, Syracuse Univ., Syracuse, N. Y....................................June 15, 1911
STERLING, ERNEST ALBERT, 1331 Real Estate Trust Bldg., Philadelphia, Pa. ....April 2, 1903
STERRETT, WILLIAM DENT, Forest Service, Washington, D. C.......Feb. 3, 1906
STUART, ROBERT YOUNG, Forest Service, Washington, D. C........June 15, 1911
SUDWORTH, GEORGE BISHOP, Forest Service, Washington, D. C.....Dec. 15, 1900
SWAN, ORRINGTON THOMAS, Forest Service, Washington, D. C.....Sept. 1, 1911
TERRY, ELWOOD I., Colorado College, Colorado Springs, Colo.......Sept. 1, 1911
TIEMANN, HARRY DONALD, Forest Service, Madison, Wis.........March 2, 1905
TIERNEY, DILLON P., Asst. State Forester, St. Paul, Minn.........June 15, 1911
TILLOTSON, CLAUDE RAYMOND, Forest Service, Washington, D. C..June 15, 1911

Date of election

TOMPKINS, HARRY JAMES, Forest Service, San Francisco, Cal......Jan. 2, 1902
TOUMEY, JAMES WILLIAM, Yale Forest School, New Haven, Conn..Dec. 15, 1900
VILES, BLAINE SPOONER, Augusta Trust Bldg., Augusta, Maine....July 23, 1908
VON BAYER, WILLIAM HECTOR, Indian Office, Washington, D. C.....May 21, 1908
WAHA, ALPHEUS OLIVER, Forest Service, Albuquerque, N. M......May 21, 1908
WARNER, JOSEPH DE WITT, Forest Service, Livingston, Mont......July 23, 1908
WEBER, WILLIAM HOYT, 151 Courtland Ave., Stamford, Conn......June 15, 1911
WEIGLE, WILLIAM G., Forest Service, Ketchikan, Alaska...........Feb. 3, 1906
WEISS, HOWARD FREDERICK, Forest Service, Madison, Wis.........June 6, 1907
WENTLING, JOHN PHILIP, University Farm, St. Paul, Minn........July 23, 1908
WERNSTEDT, LAGE VON, Forest Service, Portland, Ore.............July 23, 1908
WHITFORD, HARRY NICHOLS, Chicago University, Chicago, Ill......Sept. 1, 1911
WILBER, CHARLES PARKER, State House, Trenton, N. J............June 15, 1911
WILLIAMS, ASA STARKWEATHER, care Allis-Chalmers-Bullock, Ltd., Montreal, Canada..April 28, 1909
WILLIS, CLARENCE P., Forest Service, Portland, Ore..............Feb. 15, 1913
WINKENWERDER, HUGO, Univ. of Washington, Seattle, Wash.......Sept. 1, 1911
WIRT, GEORGE H., Dept. of Forestry, Harrisburg, Pa............March 24, 1910
WOODBURY, TRUMAN DOANE, Forest Service, San Francisco, Cal...July 23, 1908
WOODWARD, KARL WILSON, Forest Service, Washington, D. C.......Feb. 3, 1906
WOOLSEY, THEODORE SALISBURY, JR., 250 Church St., New Haven, Conn. ....March 7, 1905
WORTHLEY, IRVING TUPPER, Broad St. Station, Philadelphia, Pa...June 15, 1911
ZIEGLER, EDWIN ALLEN, Mont Alto, Pa..........................June 6, 1907
ZON, RAPHAEL, Forest Service, Washington, D. C...............March 5, 1904

HONORARY MEMBER

Date of election

CLUTTERBUCK, PHILIP HENRY, F. Z. S., F. R. G. S., F. E. S., Deputy Conservator of Forests, Naini Tal, India..................March 24, 1910

ASSOCIATE MEMBERS

Date of election

ADAMS, JAMES BARRY, Forest Service, Washington, D. C..........July 23, 1908
AHERN, GEORGE PATRICK, Bureau of Forestry, Manila, P. I.........Feb. 7, 1901
ANDREWS, CHRISTOPHER COLUMBUS, State Fire Warden, St. Paul, Minn...Dec. 13, 1900
BESSEY, CHARLES EDWIN, University of Nebraska, Lincoln, Nebr...Jan. 2, 1902
BETTS, HAROLD SCOFIELD, Forest Service, Madison, Wis...........July 23, 1908
BOWERS, EDWARD AUGUSTUS, Yale Forest School, New Haven, Conn...Dec. 13, 1900
BRISTOL, HOWARD STANLEY, Elmhurst, Newport, R. I............July 23, 1908
BRUCE, EUGENE SEWELL, Forest Service, Washington, D. C......March 14, 1905
CLEMENTS, FREDERICK EDWARD, Univ. of Minn., Minneapolis, Minn.Feb. 15, 1913
CLINE, MCGARVEY, care Forest Service, Madison, Wis............July 23, 1908
COVILLE, FREDERIC VERNON, Bureau of Plant Industry, Washington, D. C...Dec. 13, 1900

Date of election

EGGLESTON, NATHANIEL HILLYER, Jamaica Plain, Mass.............Feb. 7, 1901
ELLIOT, SIMON BOLIVAR, Harrisburg, Pa........................June 15, 1911
FAXON, CHARLES EDWARD, Jamaica Plain, Mass..................April 3, 1902
FENN, FRANK A., Forest Service, Kooskia, Idaho.................July 23, 1908
FRANCIS, DAVID ROWLAND, St. Louis, Mo.........................Feb. 7, 1901
FURNAS, ROBERT WILKINSON, Brownville, Nebr...................Jan. 2, 1902
GANNETT, HENRY, Geological Survey, Washington, D. C...........Dec. 13, 1900
HAGUE, ARNOLD, Geological Survey, Washington, D. C.............Dec. 13, 1900
HATT, WILLIAM KENDRICK, Lafayette, Ind......................April 26, 1905
HERTY, CHARLES HOLMES, Univ. of N. C., Chapel Hill, N. C......April 26, 1905
HOLMES, JOSEPH AUSTIN, Bureau of Mines, Washington, D. C.....Dec. 13, 1900
HOPKINS, ANDREW DELMAR, Bureau of Entomology, Washington, D. C..March 14, 1905
HUMPHREY, CLARENCE JOHN, Forest Service, Madison, Wis.......Feb. 15, 1913
JACK, JOHN GEORGE, Jamaica Plain, Mass........................April 3, 1902
JARDINE, JAMES TERTIUS, Forest Service, Washington, D. C......Feb. 15, 1913
KNEIPP, LEON FREDERICK, Forest Service, Washington, D. C......June 15, 1911
LAMB, GEORGE NEWTON, Forest Service, Washington, D. C.........Feb. 15, 1913
LUEBKERT, OTTO, 1341 G St. N. W., Washington, D. C.............Dec. 13, 1900
LUKENS, T. P., Pasadena, Cal................................April 26, 1905
McVEAN, M. J., Tuscola, Saskatchewan.........................July 23, 1908
MEINECKE, EMILE P., Forest Service, San Francisco, Cal..........Sept. 1, 1911
MERRIAM, CLINTON HART, Lagunitas, Cal..........................Jan. 2, 1902
METCALF, HAVEN, Bureau of Plant Industry, Washington, D. C...June 15, 1911
MILLER, JOHN M., Bureau of Entomology, Placerville, Cal.........Sept. 1, 1911
NEWELL, FREDERICK HAYNES, Reclamation Service, Washington, D. C...Dec. 13, 1900
NOBLE, JOHN WILLOCK, St. Louis, Mo............................Feb. 7, 1901
RHODES, J. E., 1221 Stock Exchange Bldg., Chicago, Ill...........Feb. 15, 1913
ROOSEVELT, THEODORE, Oyster Bay, N. Y.........................Dec. 13, 1900
SARGENT, CHARLES SPRAGUE, Jamaica Plain, Mass................April 3, 1902
SCHNEIDER, E. E., Bureau of Forestry, Manila, P. I..............Feb. 15, 1913
SHAW, ALEXANDER S., Portland, Ore...........................July 23, 1908
SMITH, HERBERT AUGUSTINE, Forest Service, Washington, D. C..March 14, 1905
SPAULDING, VOLNEY MORGAN, Desert Laboratory, Carnegie Inst., Tucson, Ariz..Jan. 2, 1902
VANDERBILT, GEORGE WASHINGTON, Biltmore, N. C.................Feb. 7, 1901
WALCOTT, CHARLES DOOLITTLE, Smithsonian Institution, Washington, D. C...Dec. 13, 1900
WALDO, JOHN BRECKENRIDGE, Macleay, Ore......................April 3, 1902
WEBB, WILLIAM SEWARD, Shelburne, Vt..........................Jan. 3, 1901
WELLS, PHILIP P., Middletown, Conn..........................July 23, 1908
WHITTLESEY, GEORGE PATTEN, Washington, D. C.................Dec. 13, 1900
WILSON, JAMES, Washington, D. C..............................Dec. 13, 1900
WOODRUFF, GEORGE WASHINGTON, Honolulu, Hawaii............March 14, 1905

DECEASED MEMBERS

Name	Membership	Date of election	Date of death
Black, Frank Swett	Associate	Jan. 3, 1901	March 16, 1913
Brandis, Sir Dietrich	Honorary	May 28, 1903	May 28, 1907
Brewer, William Henry	Associate	Feb. 7, 1901	Nov. 2, 1910
Clark, Willard Weld	Active	April 2, 1903	July 30, 1909
Cleveland, Grover	Associate	Jan. 3, 1901	June 24, 1908
Dudley, William Russell	Associate	Feb. 7, 1901	June 4, 1911
Fox, William Freeman	Associate	Dec. 13, 1900	June 16, 1909
Gardner, Wesley Johnson	Active	March 5, 1904	June 14, 1906
Gibbs, Wolcott	Associate	April 3, 1902	Dec. 9, 1908
Harrison, Benjamin	Associate	Jan. 3, 1901	March 14, 1901
Hitchcock, Ethan Allen	Associate	April 3, 1902	April 9, 1909
Hubbard, William Fairchild	Active	May 28, 1903	July 17, 1905
Jesup, Morris Ketchum	Associate	April 3, 1902	Jan. 22, 1908
Miller, Louis Christian	Active	March 7, 1905	July 16, 1910
Mohr, Charles	Associate	Feb. 7, 1901	April 27, 1902
Morton, Julius Sterling	Associate	Jan. 2, 1902	April 27, 1902
Phillips, Frank Jay	Active	July 23, 1908	Feb. 13, 1911
Pinchot, James Warren	Associate	Jan. 3, 1901	Feb. 7, 1908
Whitney, William Collins	Associate	Jan. 3, 1901	Feb. 2, 1904
Wiggins, Benjamin Lawton	Associate	Jan. 3, 1901	June 14, 1909

ERRATA

In Volume VII, No. 2, p. 213, top, a regrettable mistake has been noted. In the paragraph beginning with the word "*Chaparral,*" after the words "found in," the following words were omitted: "Southern California. The type corresponds to the scrub, elfin-wood, bush forest,"

PUBLICATIONS

Volume I, Nos. 1, 2, and 3, 1905 and 1906. 189 pages.

NUMBER 1.—Officers and Committees for 1905.—*President Roosevelt*, Forestry and Foresters.—Constitution.—Active Members.—Associate Members.—Honorary Member.—Meetings.

NUMBER 2.—William F. Hubbard, Obituary.—*F. H. Newell*, The Reclamation Law and Its Relation to Forestry.—*Edward T. Allen*, The Application and Possibilities of the Federal Forest Reserve Policy.—*George W. Woodruff*, The Disposal of Public Lands.—*Alfred Gaskill*, Silviculture Applied to Virgin Forest Conditions.—*Albert F. Potter*, Objections to the Forest Reserves in Northern California.—*George L. Clothier*, The Great Kansas River Flood of 1903.—*J. B. Lippincott*, The Necessity for Saving the Forests on the Watershed of the Sacramento River.—*W. J. Gardner*, Results of a Rocky Mountain Forest Fire Studied Fifty Years after its Occurrence.

NUMBER 3.—Meetings in 1904-1905.—*Alfred Gaskill*, How Shall Forests be Taxed?—*E. A. Sterling*, What are the Essentials of a State Fire Law?—*Bailey Willis*, Deforestation in China.—*L. C. Miller*, Chaparral as a Watershed Cover in Southern California.—*Alfred Gaskill*, Why Prairies are Treeless.—*Raphael Zon*, Principles Involved in Determining Forest Types.

Volume II, No. 1, 1907. 129 pages.

NUMBER 1.—Meetings in 1905-1906 and 1906-1907.—Wesley Johnson Gardner, Obituary.—*R. C. Bryant*, Some Philippine Forest Problems.—*E. A. Sterling*, Striking Features of the Forest and Water Situation in California.—*Ralph S. Hosmer*, Some Forest Problems in Hawaii.—*Henry S. Graves*, Some Problems in Forest Education.—*W. D. Sterrett*, Objects and Methods of Establishing Permanent Sample Plots.—*Raphael Zon*, A New Explanation of the Tolerance and Intolerance of Trees.—*Samuel J. Record*, Forest Fire Insurance in Germany.—*W. B. Greeley*, A Rough System of Management for Reserve Lands in the Western Sierras.—*T. S. Woolsey, Jr.*, Some Government Timber Sales in the Southwest from the Practical and Technical Standpoint.

Volume III, No. 1, 1908. 124 pages.

NUMBER 1.—Program of Meetings.—Announcement.—*Herbert A. Smith*, Some Further Considerations Regarding the Tolerance and Intolerance of Shade.—*Edward E. Carter*, The Silvicultural Results of Marking Timber in National Forests.—*Henry S. Graves*, Condition of American Silviculture.—*T. S. Woolsey, Jr.*, Managing a National Forest from the Business Standpoint.—*Gifford Pinchot*, Sir Dietrich Brandis.—*Austin Cary*, Influence of Lumbering on Forestry.—*E. R. Hodson*, Silvical Notes on Lodge-

pole Pine.—*Hugh P. Baker*, Some Forest Problems of the Middle West.—Constitution as amended to date.—Members of the Society.

Volume IV, Nos. 1 and 2, 1909. 230 pages.

NUMBER 1.—Program of Meetings.—*Arthur Bernard Recknagel*, The New Reconnaissance: Working Plans that Work.—*Samuel Trask Dana*, Experiment Stations in Connection with the National Forests.—*Ernest Albert Sterling*, Forestry for Railroads.—*Clifford Robert Pettis*, Problems in Nursery Practice.—*Professor F. E. Clements*. Plant Formations and Forest Types.—*Joseph T. Rothrock*, Relation Between State and Private Forestry in Pennsylvania.—*Ralph Clement Bryant*, Some Notes on the Yellow Pine Forests of Alabama.—*Gordon E. Tower*, A Study of the Reproductive Characteristics of Lodgepole Pine.—*Theodore S. Woolsey, Jr.*, Preliminary Forest Management in the Southwest.—*H. H. Chapman*, Timber Estimating.—Department of Discussions.

NUMBER 2.—*William L. Hall* and *Hu Maxwell*, The Relation of Surface Conditions to Streamflow.—*Charles H. Shinn*, Shakes and Shake-making in a California Forest.—*Edwin Allen Ziegler*, The Standardizing of Log Measures.—*Howard F. Weiss*, Wood Preservation: A Determining Factor in Forest Management.—*Fred W. Besley*, Forest Mapping and Timber Estimating as Developed in Maryland.—*Herman H. Chapman*, A Method of Studying Growth and Yield of Longleaf Pine Applied in Tyler County, Texas.—*Morris Kozenik*, A New Method of Planting (Translated from the German).—Obituary: William Freeman Fox and Willard Weld Clarke.

Volume V, No. 1, 1910. 151 pages.

NUMBER 1.—*Henry Solon Graves*, The Selection System.—*Harry D. Tiemann*, The Log Scale in Theory and Practice.—*Carlos G. Bates*, Experiments in Sandhill Planting.—*W. W. Ashe*, Management of Loblolly and Shortleaf Pines.—*S. L. Moore*, Regulating the Annual Cut of National Forests.—*Fred G. Plummer*, The Growing of Eucalypts.—*Treadwell Cleveland, Jr.*, Forests as Gatherers of Nitrogen.—*C. D. Mell*, Basket Willow Culture in Germany.—Obituary: Samuel Bowlear Green and Louis Christian Miller.

Volume VI, Nos. 1 and 2, 1911. 270 pages.

NUMBER 1.—Summary of the Secretary's Report for the Year Ending December 31, 1910.—Summary of the Treasurer's Report for the Year Ending December 31, 1910.—Report of the Committee on New Work.—*Dr. Chas. E. Bessey*, In Memoriam: Frank Jay Phillips.—*Burt P. Kirkland*, Working Plans for National Forests of the Pacific Northwest.—*T. S. Woolsey, Jr.*, Strip Thinnings.—*A. E. Oman*, Hardy Catalpa: A Study of Conditions in Kansas Plantations.—*Carlos G. Bates*, Forest and Streamflow: An Experimental Study.—*Dr. H. N. Whitford*, The Philippines as a Source of General Construction Timbers.—*Charles H. Shinn*, Economic Possibilities of *Pinus sabiniana*.—*C. D. Mell*, History of the Investigations of Vessels in Wood.—*Dr. E. Zederbauer* (Translated from the German by *Max H. Foerster*), Experiments in the Preservation of Forest Seeds.—*R. L. Rogers*, Eucalyptus Possibilities on the Coronado National Forest.—*Swift Berry*, Notes on Management of Redwood Lands.—*Charles S. Judd*, Efficacy of Goats in Clearing Brush Lands in the Northwest.

NUMBER 2.—*Barrington Moore*, The Essentials in Working Plans for National Forests.—*Dr. B. Herstein*, Conservation and Chemical Pulp.—*Raphael Zon*, Seed Production and How to Study It.—*W. B. Greeley*, Better Methods of Fire Control.—*I. E. Eldredge*, Fire Problem on the Florida National Forest.—In Memoriam: William Russell Dudley.—*Helen Stockbridge*, Bibliography of Southern Appalachians.—Amended Constitution.—List of Members.

Volume VII, No. 1, 1912. 129 pages.

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THE TECHNIQUE OF SEED TESTING

BY C. G. BATES

Contributed

The purpose of this paper is not primarily to set forth *facts* which for the most part have been but meagerly proven, but rather to use such facts as have been obtained from the seed-testing in District 2 as the basis of a discussion of *methods* which, it is strongly felt, should be standardized among all American foresters and seed dealers as soon as sufficient experience is gained to make this possible.

The facts stated, however well proven, must not be construed to apply to species other than the principal ones occurring in the central Rocky Mountains, nor will the findings from these facts to any large extent apply to the same species as they occur in other regions. It must not be overlooked that the seed of any particular species probably has the same number of climatic or geographic forms as does the tree itself. Seeds from different localities may not differ in size, color, or weight, but nevertheless may show very different responses to the conditions which induce germination. These different responses can only be construed as climatic adaptations. Thus, in general, the more rapid and vigorous germination of southern seed, as compared with northern seed of the same species, is undoubtedly the result of adaptation to conditions which demand rapid germination or the extinction of the species. The climatic conditions which produce this characteristic are probably high temperatures and rapid evaporation. It may be conceived that the germination of seed in nature is independent of the amount of precipitation. It is not a question of how wet the seed-bed becomes at times, but how long it remains in a favorable condition.

For such reasons as this it is apparent that the procedure in seed-testing, and especially the period allowed for germination, must be adapted to the region in which the seed is to be used. Nevertheless, certain definite laws for determining procedure can probably be laid down, and it is one of the objects of this paper to show how such laws are being worked out and their usefulness.

General Value of Seed-testing.

The value of germination tests on all seed used in reforestation cannot be overestimated. No other means is at hand for determining accurately the value of the seed to be sown in the nursery or in the field, and seed tests make possible the most economical use of seed, while at the same time insuring the use of sufficient seed to obtain the desired stand if the field conditions happen to be favorable. Thus in a broad-casting operation one might sow two pounds of seed to the acre on the assumption that the particular lot of seed in use had a germinative value of 75 per cent, and if it proved to be the case that the seed had a germinative value of only 35 per cent, the expected stand would not be secured even under the most favorable conditions, and the expense of resowing would be necessitated, making the ultimate cost of the plantation almost double what it should be. On the other hand, in seed-spot sowing or in nursery work an accurate knowledge of the value of the seed makes it possible to sow without danger of securing an overcrowded stand or of wasting seed.

Mathematical Accuracy of Seed Tests.

The work of making germination tests must never be thought of as a mathematical art. Innumerable factors enter into any single test to reduce its accuracy. From a hundred pounds of seed, with more or less foreign matter in mixture, it is impossible to take a perfectly representative sample. Even after a small sample of, say, 2,000 seeds has been perfectly cleaned and laid out on a table, it is impossible to select from this lot two samples of 500 seed each which will have the same weight or specific gravity. A single case of this kind showed a difference of about 6 per cent in the weight of two samples which were taken in an ordinary manner from a small conical pile of seed. It must be apparent, therefore, that to obtain results of any value at all extremely careful sampling is necessary. Even after this has been done the conditions for germinating two or more samples of seed cannot be made perfectly uniform, and further errors enter into the result. A test made at the Fremont Experiment Station on ten lots of yellow-pine seed, of 500 seed each, from the same initial lot of seed, showed germination results in

twenty-five days varying from 44.2 per cent to 72.4 per cent, and the mean variation from the mean germination per cent was 6.83 per cent. This occurred with a species which usually germinates very vigorously and promptly, and with species which are subject to greater variations in the period of germination the probable error with any single lot of seed is likely to be even greater.

Character of Germinating Apparatus.

It has undoubtedly been shown by experience in every locality where numerous seed tests have been made that the soil test is most satisfactory. It is not the most satisfactory because it gives the highest values and the most prompt results, but because it is the most natural method of germinating and gives the most uniform results—results which bear a certain relation to those which may be expected in field germination. Yet in spite of this fact various forms of blotter and wick germinators are suggested and urged upon the forester and are much used. It is sufficient to say, in criticism of the use of such apparatus, that the results are not comparable with results from soil tests and that it is almost impossible to standardize the germinating processes with such apparatus.

At the Fremont Experiment Station the first germinating apparatus used was called the "fireless-cooker germinator." It consisted of a large wooden box within which was a water-tight tank with 6 inches space between the walls of the tank and the walls of the box. This space was filled with excelsior, forming a very perfect insulation against radiation. Within the tank was a smaller tank with 3 inches space between the walls. The space between the two tanks was filled twice daily with water at a temperature of 90° F. During the twelve-hour period in which this water remained, the temperature seldom dropped below 75° F. There was, therefore, during each period of twelve hours a change of 15° in the temperature of the inner tank or germinator. The seed samples were placed in petri dishes within the smaller tank. Each dish contained a layer of moist blotting paper, and the seed lay upon this. Evaporation from the germinator as a whole was so slight that the blotters retained their moisture for a number of days. The principal objections to this form of germinator were: (1) the total absence of sunlight, which is thought to have an appreciable influence on seed germination; (2) the occurrence of moulds and other fungi on the blotters and on the seed, which necessitated the use of a fungicide such as formalin, both the moulds and the fungicides undoubtedly affected the germination of the seed; (3) there being no system of drainage for the dishes, it was almost impossible to wet all samples uniformly.

The results obtained in this germinator were anything but satisfactory. On any group of samples placed in the germinator simultaneously, germination varying from 2 per cent to a total value of 60 or 70 per cent might be expected. While yellow pine usually germinated very satisfactorily, it is now believed that complete germination with lodgepole pine was never secured under these conditions. One particular sample of lodgepole, which would not germinate at all here, showed a value of 33 per cent by soil tests made in Washington.

As soon as the seed-testing work for District 2 was systematically taken over by the Experiment Station, soil tests in the greenhouse were begun. Owing to the gravelly nature of the soil at the station, it was considered best at the outset to use the surface soil, which contained the smallest proportion of large gravel and the largest proportion of humus and loam. To obtain a sufficient quantity of this soil, it was, of course, necessary to scrape considerable ground, and as a result the different lots of soil used during the winter of 1911–1912 were not uniform in character. In most cases no crusting in the greenhouse was noticed, but in those cases where crusting did occur the tests were, of course, vitiated and made not comparable with the others. The greatest difficulty, however, arose from the fact that this rich, loamy soil was conducive to the growth of moulds; and, while it was not definitely determined that any of these fungi became parasitic upon the seed or seedlings, it was considered desirable in starting each new test to use soil which had been sterilized. The dry-sterilizing or baking process in turn affected the physical properties of the soil, so that after any particular lot of soil had been used two or three times it was not at all like soil freshly taken from the ground.

As has been stated, both the surface and subsoil at the Experiment station is largely composed of disintegrated granite. However, it was found to be possible, in deep excavations, to obtain, by sifting, a sand which was almost entirely free from humus. The use of sand was, therefore, begun during the summer of 1912, and it is now believed that the expense of obtaining this sand is thoroughly justified by the results. No single lot of sand is used more than once, and at no time during the season has there been any appreciable amount of mould in the greenhouse. The principal advantage is the uniform texture of the sand and its slight retentive power for moisture, which makes it drain readily and makes it almost impossible for one till of the sand to have more moisture than another. The use of sand has slightly affected the amount of germination obtained in any given period, the tendency being to germinate more rapidly in sand than in loam.

Germinating Temperatures.

It is a well-known fact that a regular change of temperature during each twenty-four-hour period, if restricted to certain limits, stimulates the germination of seed. For example, germination would probably be more rapid and vigorous where the temperature reached 90° during the day and dropped to 50° at night than where it was constantly at 70°. For this reason, and because the facilities at the station would not permit of maintaining a uniform temperature in the greenhouse without great expense, the daily range was established at the outset at 30°, the extremes to be 55° and 85° F. During the spring, summer, and fall these temperatures are maintained largely through regulation of the ventilation of the greenhouse. During the winter artificial heat is necessary to prevent too low a temperature at night and on cloudy days to attain the maximum desired, but on sunny days very little artificial heat is required even in the coldest weather. The greenhouse is so situated and constructed that there is practically no radiation from the walls; and, if it were necessary, radiation could be almost entirely prevented by covering the glass surface with canvas at night. The walls of the greenhouse are of concrete, 8 inches thick, and two-thirds of the building are under ground.

Depth of Covering.

With the beginning of germination tests in the greenhouse the entire available bench space was divided into tills 4 inches deep and 12 inches square, separated by partitions one-half inch thick. These tills are not quite as satisfactory as movable flats on account of the difficulty of cleaning the soil out of them when a seed test is completed, but they have considerable advantage in initial cost. Whenever a new test is started in any till, the till is filled level full with loose and freshly mixed soil, which is then pressed down by means of a board which exactly fits the inside dimensions of the till. This board has stoppers which catch on the edge of the till and prevent its being pushed down more than the depth desired for the seed covering. When the board is removed a perfectly smooth soil surface is left, with the soil underneath fairly compact and with the depth of the surface below the edges of the till uniform in all parts. The seed is strewn evenly over this surface and the till is again slightly more than filled with loose soil, the superfluous soil being scraped off by means of a straight-edge which rests on the edge of the till. Thus both *uniform conditions under the seed* and *uniform depth of covering* over the seed are secured.

At the outset it was thought advisable to vary the depth of covering for different species somewhat in accordance with the size of the seed,

since in field or nursery sowing a similar practice is almost universally observed. The rule was established that with species of conifers whose seed averaged 10,000 to the pound or less, the depth of covering would be one-half inch. Species averaging 10,000 to 30,000 to the pound would be covered three-eighths inch, and seeds of species averaging over 30,000 to the pound would be covered one-fourth inch. There was no objection to this procedure, except as evidence was secured that the one-half-inch covering for yellow pine, whose seed averaged less than 10,000 per pound, was slightly too great and retarded germination. This was very apparent with the loam covering, especially in tills where the soil had a tendency to crust, and even after the use of sand was inaugurated the one-half-inch covering was shown to have a retarding effect, as shown by the following table:

TABLE 1.—*Germination of Western Yellow Pine in Loam and Sand—Heavy and Light Coverings.**

Depth of covering	Germination in loam †				Germination in sand			
	Force	Capacity	Ratio between force and capacity	Force period	Force	Capacity	Ratio between force and capacity	Force period
	Per cent	*Per cent*	*Per cent*	*Days*	*Per cent*	*Per cent*	*Per cent*	*Days*
¼ inch....	51 8	63.3	81.8	22.8	56.2	58.8	95.6	24.6
½ inch....	43.3	58.9	73.5	29.8	51.2	55.4	92.4	27.0

As a result of this and other investigations, shortly after the use of sand was begun the covering was made uniform for all species, and is now stipulated at one-fourth-inch. Yellow pine is the only commonly tested species in District 2 whose seed might have a heavier covering, and not more than three-eighths-inch covering could be considered for it.

Period of Germination.

Undoubtedly the most important consideration in obtaining comparable germination data on various lots of seed is the period allowed for germination. For economical reasons the ordinary commercial seed test—that is, a test made to determine the value of seed for ordinary use in forestation—cannot be run indefinitely, or even until germination has practically ceased. Even aside from the item of the cost of such a test, the complete or final germination of a lot of seed cannot be used as

* There is no comparison possible between sand and loam germination except by means of the ratios between force and capacity, because different seed lots are involved in the two groups of tests.

† Some data lacking for some tests, and number of tests only 5.

a measure of its value in the field. It has been definitely shown by experience in Germany that while the field value of a lot of seed which germinates vigorously and fully under test conditions may be very near the value shown by the test, the actual value of a seed lot which germinates more sluggishly and produces only a low per cent of final germination is comparatively small. To illustrate the principle, it may be said that a lot of seed which shows 90 per cent germination by test might be expected to show 80 per cent germination in the field, while one which tested only 50 per cent could be expected to germinate only to the extent of 25 per cent in the field.

Our own experience has shown that the germination of poor seed in a limited period is a much smaller percentage of the final germination than is the germination of good seed in a limited period. While, therefore, the setting of a definite limited period for the germination of any particular species may not give results exactly comparable to those obtained in the field, it is to be seen that this germination in a limited period must bear a much more definite relation to the field germination than would the final germination under test conditions. In other words, by limiting the period of germination in seed testing, we to a large extent eliminate the factor of variability in field results due to the use of poor seed. The relative germination of a large number of poor, medium, and good lots of seed tested at the Fremont Station is shown by the following table:

TABLE 2.—*Relative Amounts of Vigorous Germination in Different Grades of Seed.*

Datum	Species	Germinative force	Germinative capacity	Ratio between force and capacity
		Per cent	*Per cent*	*Per cent*
10 samples 30–50% capacity...	Lodgepole pine.	28.26	41.44	68.2
27 samples 50–60% capacity...	Lodgepole pine.	43.70	55.06	79.4
28 samples 60–70% capacity...	Lodgepole pine.	55 94	65.33	85.6
23 samples 70–80% capacity...	Lodgepole pine.	65 66	74.55	88.0
3 samples 80–90% capacity...	Lodgepole pine.	80.07	84.27	95.0
5 samples 20–40% capacity...	W. yellow pine.	25.00	29.68	84.3
11 samples 40–60% capacity..	W. yellow pine.	43.24	48.38	89.5
7 samples 60–80% capacity...	W. yellow pine	61.06	67.11	91.0
6 samples 80–100% capacity..	W. yellow pine.	88.23	90.73	97.2
3 samples 0–20% capacity...	Douglas fir.....	10.07	13.27	75.9
5 samples 20-40% capacity..	Douglas fir.....	23.20	31.08	74.7
15 samples 40–60% capacity...	Douglas fir.....	36.52	48.91	74.7*
5 samples 60–80% capacity...	Douglas fir.....	70.44	76.20	92.4*
4 samples 80–100% capacity..	Douglas fir.....	83.05	86.80	95.7

* This sudden rise in the ratio is due to the absence of Wyoming samples from the two highest grades.

When seed-testing work was seriously begun at the Fremont Station a rather daring assumption was made. It was assumed that for forestation purposes in the central Rocky Mountains, where conditions for germination are seldom really favorable and where the period of moderately favorable conditions is almost always short, only the very vigorous germination shown under greenhouse conditions would be worth considering under field conditions. The straggling germination which occurred after the seed had been in the greenhouse, say, 25 days would count for nothing in the field, because after seed had been in the field for 25 days or more, conditions would be very unfavorable for germination in most cases. In the nursery this rule would not hold so definitely; yet even there, where conditions for germination may be maintained indefinitely by artificial watering, it is a well-known fact that the straggling, late seedlings come to little or nothing because of their susceptibility to attack by damping-off fungi.

On the above assumption a "germinative energy" (or more commonly called "germinative force") period for each species was established. This was done for the purposes of District 2 by a study of the germination of ten or more samples of each species from different parts of the district. Five hundred seed of each sample having been sown, the rule was adopted that the germinative force period for any sample had terminated when the germination in any single day dropped below two seedlings, if on the following day the number of seedlings did not exceed two. It was found that with yellow pine, lodgepole pine, and Engelmann spruce the period of vigorous germination for various individual samples was very uniform, and for each of these species an average period was readily established. With Douglas fir, however, of which about equal numbers of samples were from Colorado and Wyoming, a wide discrepancy existed, it being found almost without exception that the samples from the northerly latitudes required a much longer time to complete their vigorous germination than samples from southerly latitudes. For this species, therefore, two distinct periods were decided upon. The period to be considered, as will be shown later, depends not so much upon the source of the seed as upon the place where the seed is to be used.

The force periods have been to some extent modified by the change from loam to sand in the greenhouse, and at present stand as follows for the four important species:

Yellow pine	**25 days**
Lodgepole pine	**31 days**
Douglas fir—for Wyoming use	**35 days**
Douglas fir—for Colorado use	**21 days**
Engelmann spruce	**22 days**

The question at once arises as to what assurance may exist that the limiting of the period of germination will not introduce a great error and thwart the purposes of the test, which are to effect economy in seed. It must be admitted that any sample of lodgepole pine, for example, may under very favorable field conditions germinate to a greater extent than is indicated to be possible by the limited greenhouse test. Nevertheless, the correctness of the principle has been demonstrated. During the season of 1912 there were sown at the Fremont Experiment Station samples of 10 lots of seed each of yellow pine, lodgepole pine, and Engelmann spruce, and 15 lots of Douglas fir, under the most favorable field conditions that could possibly be expected in any forestation project in this region. Each of these lots had previously been tested in the greenhouse and was sown both in the spring and in the summer, and each lot was again tested in the greenhouse in the fall of 1912. The method of sowing each lot in the field was to prepare an extremely large seed-spot, 4 x 4 feet, stirring up the soil in this area with a grub-hoe, leveling the surface, scattering the 500 seeds over this surface, and covering them evenly with a measured amount of soil. Each individual lot of seed under test was given a separate seed-spot, and each seed-spot was surrounded by unbroken ground, so that the conditions roughly approximated those existing in an ordinary seed-spot sowing operation. Each of these spots was protected by a screen cover, so that the element of rodent damage was absolutely eliminated. As has been stated, these conditions approach the ideal of field conditions, and are the only field conditions worth considering, since it would be wholly useless to attempt to make tests of seed which would hold good under various degrees of unfavorable field conditions. The average results with the four species tested, up to the end of 1912, are shown in the following table:

TABLE 3.—*Relation of Greenhouse Germination in Limited Period and Field Germination under Most Favorable Conditions.*

Datum	Western yellow pine	Lodgepole pine	Douglas fir (Colorado only)	Engelmann spruce (Colorado only)
Germinative energy before field test	41.4	58.4	42.47	39.3
Total germination from spring field sowing	38.3	12.0	42.41	35.3
Total germination from summer field sowing	18.62	37.5	17.64	39.0
Germinative energy after field tests	42.2	58.4	44.08	47.2
Days allowed for "energy" period in greenhouse	25	27	21	22

From this it is seen that the best field germination of yellow pine fell 3.5 per cent below the mean greenhouse value; of lodgepole, 20.9 per cent; of Douglas fir, 0.9 per cent, and of Engelmann spruce, 8.0 per cent.

In some cases the field germination is probably not complete. Experience has shown that any of our four important species, but more particularly lodgepole pine and Engelmann spruce, may show considerable germination during the second season after sowing. The fact that the germinative "energy" per cent obtained in a limited number of days is a sufficiently liberal figure to express the field value of the seed is, however, pretty well proven. The individual tests show a general parallelism between this "energy" per cent and the field results, interrupted, to be sure, by numerous exceptions which do not disprove the rule.

Seed Conditions Affecting Germination.

While, of course, it must be admitted, especially where artificial heat is used in extracting seed from the cones, that originally good seed may have been more or less damaged in the extracting operation, it is a fact which has been quite conclusively proven in the mind of the writer that the moisture condition of the seed itself at the time when it is placed in the greenhouse is of the utmost importance. Thus the astounding fact has been observed, particularly with lodgepole pine, that of two lots of seed which are germinated immediately after they have been extracted from the cones, that lot which is the drier will germinate the more vigorously. On the other hand, the lot which is in the drier condition will, after several months of air-tight storage, show no improvement or may even show deterioration, while the moister lot of seed will have greatly improved. This fact has now been determined for a large number of samples, and has been the means of explaining a great many phenomena which were previously unexplainable. The general principle could not be better illustrated than by the following test, which involved thirty distinct lots of seed from three forests in District 2 (see Table 4).

The most noteworthy feature of this table is the high initial "energy ratio" of the dry seed and its lack of change in eight months, while the ratios for the moist seed increased materially. The shortening of the "energy period" for the moister seed is equally remarkable. The age of the seed has, of course, a direct influence on its germination. Under very favorable conditions of storage, such as are obtained in airtight receptacles and in a room or building with a low, even temperature, depreciation of seed with age may be very slight for a number

TABLE 4.—*Immediate and Later Germination of Dry and Moist Seed.*

Datum	Seed drier than air 0.0 to —2.0 % moisture	Seed containing 0.1 to 1.0 % moisture	Seed containing 1.1 to 2.0 % moisture
Original germinative energy, per cent	64.08	53.44	50.09
Original germinative capacity, per cent	69.88	63.58	61.02
Ratio, energy to capacity, per cent	91.7	84.0	82.1
8-month germinative energy, per cent	68.20	65.42	62.40
8-month germinative capacity, per cent	74.28	72.60	69.42
Ratio, energy to capacity, per cent	91.8	90.2	89.9
Energy period, original (days)	26.6	31.5	35.7
Energy period, 8-month	26.5	27.7	26.9

of years, while under less favorable conditions depreciation may be rapid. It is believed that all experiments on this subject which have so far been made have almost entirely overlooked the question of the moisture condition of the seed itself at the time when placed in storage. The data given in the above table tends to show that, at least for short periods, the best results in storage are obtained where the seed contains about 1 per cent more moisture than air-dried seed. Just what amount of absolute moisture this represents is not known, but it is believed that the subject is worthy of thorough investigation, which it is now being given in District 2.

Old seed may not show any material decrease in its final germination, but will show a tendency to germinate much more slowly than fresh seed.

Various Criteria of Seed Values.

The criterion of seed values which should be used for comparing different lots of seed must depend very largely on the purpose of the comparison. As has been shown, the germinative "energy" is theoretically and actually the best criterion of the real value of the seed for field sowing and makes possible a standardizing of seed values for seed to be used within certain geographic confines.

For scientific purposes, as, for instance, in comparing the seed from different localities or different kinds of trees, or for comparing the seed from the same locality during a period of years, undoubtedly the best criterion is the final germination or germinative capacity. In District 2 the seed tests have never been allowed to run until germination had absolutely ceased, but the germinative capacity has been measured in twice the number of days allowed for showing the germinative energy. In the case of lodgepole pine, thirteen samples showed the following

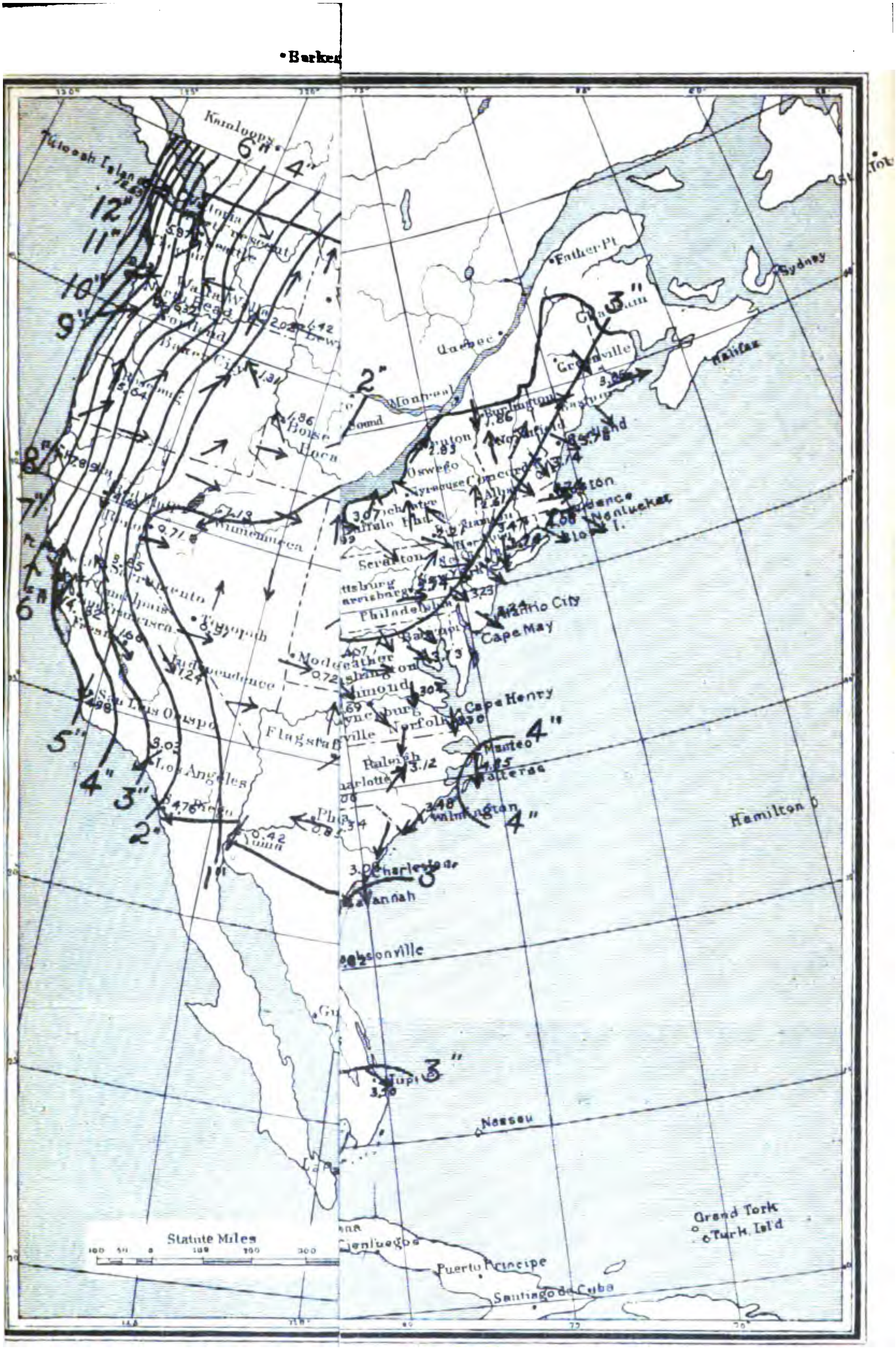
results. (The average "energy period" for these lots, established as described in this paper, was 35 days, being slightly greater than the mean for the species.)

Germinative energy, 35 days	45.48 per cent
Germinative capacity, 70 days	67.14 per cent
Final germination, 96 days	71.30 per cent

From the above it is seen that with lodgepole, the most slow-germinating of our species, the germination occurring after the termination of the arbitrary capacity period averages only 4.2 per cent. The individuals showed a maximum of 7.1 per cent and a minimum of 1.8 per cent, this excess bearing no definite relation to the total germination. With yellow pine and the more rapid-germinating species the germination after the termination of the force period is seldom more than this, making it evident that for any purpose demanding reasonably complete germination the capacity germination is entirely adequate.

For the purpose of investigations which involve different methods of treating the cones or seed, neither the germinative energy nor the germinative capacity are wholly satisfactory criteria. This, it is believed, is largely because of the impossibility, either in taking samples of cones or seed for different treatments, of getting thoroughly uniform samples, and there will, therefore, in the several samples be inherent differences which will affect the absolute germination. Such differences may entirely obscure the point which it is sought to demonstrate; for instance, by different methods of extracting or different methods of cleaning the seed. On the other hand, the ratio of germinative energy to germinative capacity is usually about the same for different lots of seed grown under similar conditions and which have undergone the same treatment. This ratio, therefore, will show more clearly than any other figure the effects of different treatments in extracting, storage, etc., and is the best criterion for investigative purposes.

From the foregoing discussion it must be seen that the problems met in seed-testing work are decidedly complicated, and, since it must be admitted that seed-testing is very important work, the desirability of standardizing the methods and conditions of forest-tree seed-testing in the United States cannot be too strongly emphasized.



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THE RELATION OF FORESTS IN THE ATLANTIC PLAIN TO THE HUMIDITY OF THE CENTRAL STATES AND PRAIRIE REGION

BY RAPHAEL ZON

Delivered before the Society December 14, 1911

INTRODUCTION

Many of the dreams or presentiments of the early scientists are now coming true every day. The dreams of the alchemists are now almost within the realization of modern chemistry. The gropings of the early biologists are almost within reach of present-day experimental embryology, and so on practically in every science; at first a presentiment, "a hunch," which cannot be substantiated by any scientific facts. This, later, with the accumulation of more accurate observations, is often entirely denied or minimized, only to reappear, not as a presentiment any more, but as a scientifically established fact.

From the earliest times there existed among laymen, and even scientists, a belief that forests exercised an influence upon the climate of entire countries. With the introduction of accurate methods of meteorological observations, this popular conception has seemingly been greatly discredited. All that most of the meteorologists were willing to admit was that forests have a local influence upon climate, extending only over the territory actually occupied by them. Within recent years, just when this view seemed to be completely disposed of, many new facts came up independently in different countries, which point strongly to the possibility of the forest exerting a potent influence upon the humidity of regions lying far away from it. I shall attempt to consider in the light of these new facts the conditions prevailing in the eastern part of the United States, and to establish a relation between the forests of the coastal plain and the southern Appalachians, on the one hand, and the humidity of the Central States and prairie region, on the other.

There are three fundamental facts upon which, in my judgment, this relation is based:

1. In the eastern half of the United States there is a marked periodicity in the wind direction. In winter the prevailing winds are from the north and northwest; in summer they are from the south. When the prevailing winds come from the south the entire eastern half of the

United States is wet. When the prevailing winds are from the northwest and west the precipitation decreases. Therefore, the precipitation of the eastern half of the United States depends largely upon the prevailing southerly winds which come from the Gulf and penetrate far into the interior of the continent.

2. The evaporation from the ocean plays a comparatively unimportant part in the precipitation over the land; seven-ninths of the precipitation over land is supplied by evaporation over the land itself, and only two-ninths is furnished by the evaporation from the ocean. Therefore, the greater the evaporation from the land which is in the path of the prevailing southerly winds, the more moisture must be carried by them into the interior of the continent.

3. The forest evaporates more water than any vegetative cover and much more than free water surfaces. Therefore, forests enrich with moisture the winds that pass over them, and contribute to the humidity of the regions into which the prevailing air currents pass.

PERIODICITY OF WIND DIRECTION IN THE EASTERN HALF OF THE UNITED STATES

After Asia, North America is the largest continent in the world. One of the most striking physiographical features of North America is that the mountains run along the meridians and not along parallels. The entire northern part of the American continent has no high mountains except in the western part. As the result of this the central part of the continent does not offer any obstruction to winds from the 30th to 70th degree of northern latitude; that is, from the Gulf of Mexico to the Arctic Sea. (Even the Asiatic continent does not have such a large continuous area free of mountains extending along the meridian. There the greatest extension is from the 38th to the 73d degree of northern latitude; that is, from the southern border of the plain of Turan to the northern shores of western Siberia.) To the south of the 30th degree extend the waters of the Gulf of Mexico. The mountains on the southern shore of the Gulf begin only at 19 degrees of north latitude. The North American continent, therefore, together with the interior lakes, forms an expanse for the movement of the air between the tropical and Arctic regions, such as is found outside of it only on large oceans; in the northern hemisphere, on the Atlantic Ocean.

Another climatic peculiarity of the eastern United States which has a bearing upon the question under discussion is the rapid decrease in temperature from south to north. Take, for instance, Labrador; it is entirely an Arctic region, where agriculture is impossible. Yet it lies

in latitudes at which in Europe and Asia agriculture is still flourishing and large, populous cities are found (in 53d to 60th degree northern latitude are found Christiania, St. Petersburg). Florida, on the other hand, between 25th and 30th degree of north latitude, is almost a tropical country. Between Florida and Labrador the drop of temperature for each degree of latitude (60 miles) is for January 2.9° F., for July 1.08° F., and for the entire year 1.7° F. Comparing the same latitudes in Europe the drop for each degree of latitude is less than half of that for the North American continent. Between the Canary Islands and northern Scotland the decrease in the mean annual temperature for one degree of latitude is only 0.8 of a degree.

Climatically the North American continent can be divided into three parts:

1. The narrow strip along the Pacific Ocean, which is separated from the interior of the continent by mountain ranges. This narrow strip from the Peninsula of California to the southern shore of the Peninsula of Alaska, from the 32d to the 60th degree of northern latitude, is under the influence of the Pacific Ocean, as it is open to the west, while in the east high mountains separate it from the interior of the continent; and as western winds are, as a rule, the strongest winds in the northern hemisphere, it is only natural that westerly and northwesterly winds prevail in this part of the country, both in summer and winter.

2. The region of mountains and plateaus to the east of the Cascades and Sierra Nevada ranges. This extends not only to the Rocky Mountains, but beyond the Rocky Mountains to the 100th meridian. The high plateaus and the low valleys of this region are characterized by extreme dryness, and only in the mountains does the snow and rain fall in any abundance. The dryness is due to the fact that the prevailing westerly winds give off the moisture on the western slopes of the Sierra Nevada and Cascades, and become dry winds on the leeward side of these mountains. During the winter the prevailing winds are from the west and northwest, but in the summer the direction of the wind changes considerably, becoming southwesterly. This change in the direction of the wind in summer has been observed even on Pikes Peak, but is still more pronounced in the valleys and on the plateaus.

3. Since the Appalachian Mountains do not offer a climatic boundary, the entire eastern part of the North American continent east of the 100th meridian can be considered climatically as one unit. This climatic region is the largest of the three, including the Atlantic plain, the Mississippi Valley, except the upper part of its western tributaries, and the Lake region to the Hudson Bay. During winter and partly

in the fall and in the early spring the winds in this region come from the west and northwest. These prevailing winds bring cold and comparatively dry air from the interior of the continent. In the spring and early summer these winds are hot and dry. In summer the prevailing winds are from the southeast in Texas, and farther north and east they come from the south and southwest. Professor Henry, in his "Climatology of the United States," says that in midwinter northwesterly winds prevail uniformly over the Missouri Valley and the upper and middle portions of the Mississippi Valley. As the spring advances, the region of southeast to south winds spreads northward and eastward from the Texas coast, so that by April it embraces the States of Texas, Oklahoma, Arkansas, Mississippi, Louisiana, Alabama, western Tennessee, Missouri, Kansas, southeastern Nebraska, and Iowa. By June the northwest winds of midwinter have been supplanted by southerly winds over practically the whole of the country east of the Rocky Mountains. In autumn the northwest winds become more frequent, and as autumn shades into winter they gain the ascendency in the Missouri and Mississippi valleys and the plain States.

The periodicity is well illustrated on the two maps, on which are indicated by arrows the direction of the prevailing winds, based on twenty years of continuous records, and by lines and colors the mean precipitation for the months of July and January. The map for the month of July is typical for the summer period, and the one for the month of January is typical for the winter period. These maps show very clearly, it seems to me, that the eastern half of the United States is under the influence of two prevailing winds; one, which originates in the Gulf of Mexico and in the Atlantic Ocean, is mild and humid; the other, which comes from the interior of the continent and from the Rocky Mountain region, is dry and continental in character; that is, dry and cold in winter and dry and hot in the spring and summer.

Another important fact which the records of precipitation and wind direction establish is that there is a most intimate relation between the prevailing southerly winds and precipitation in the eastern half of the United States. It is during the summer period, when the entire eastern half of the United States is under the influence of the southerly winds, that most of the precipitation falls over it. On the plains east of the Rocky Mountains the summer rainfall forms from three-fourths to four-fifths of that of the entire year. You will notice that in July, when the southerly, southwesterly, and southeasterly winds extend far into the interior of the continent as far north as North Dakota and as far west as the foothills of the Rocky Mountains and even into eastern New

Mexico and as far east as New England, the precipitation over the entire eastern half of the United States is very heavy. In winter the picture of both wind direction and precipitation is radically changed. The northerly and northwesterly winds have not the same pronounced persistence as the summer winds. Yet, through the entire South—Texas, Louisiana, and Mississippi—as well as the Atlantic States, the Lake States, and the Central States, the prevailing winds are northerly and northwesterly. At the same time there is a perceptible decrease in precipitation through the entire eastern half of the United States, and where in July there fell as much as three inches of rain, in January there is less than one inch, and where in July there fell as much as five inches, there is in January less than two inches.

This increase and decrease in precipitation over the eastern half of the United States, with change in the direction of the wind, points to the fact that the eastern half of the United States depends for its moisture upon the prevailing southerly winds, which originate in the Gulf of Mexico and the Atlantic Ocean.

Professor Willis Moore, therefore, is entirely right, it seems to me, when he claims that the Pacific Ocean has little influence upon the precipitation of the eastern half of the United States, as Gannett and Bailey Willis have tried to prove. It is possible that some of the vapor that originates in the Pacific Ocean drifts over the tops of the mountains and during winter is drained of its moisture by the excessive cold. This moisture may be precipitated in the form of snow over such States as North Dakota, but the amount cannot be very great.

The central interior region of the United States is thus the battleground of two titanic forces, of which one is harmful and the other is beneficial. The beneficial force takes its origin in the Gulf of Mexico and the adjoining ocean, the harmful in the interior of the continent and the Rocky Mountain region, and whether it comes as the warm Chinook winds which blow out of the northern Rocky Mountains, or as the dry westerly winds of the upper Mississippi Valley and the western Lake region, occurring especially in the spring and early summer, it always carries in its wake serious injury to orchards and fields.

The Central States and the prairie region are geographically at the point where the battle between the two forces is fiercest and the victory is now on the one side and now on the other, being dependent upon the cold and humid, and the warm and dry, climatic cycles as well as upon the seasons of the year.

When the humid southerly winds extend their influence far into the interior of the continent and overpower the dry continental winds, the

Central States and prairie region, the granary of the United States, produce large crops. When the dry winds overpower the humid southerly winds there are droughts and crop failures.

The southerly winds on their way from the Gulf of Mexico do not meet any mechanical obstructions. Since the Appalachian Mountains, running in a northeasterly and southwesterly direction, do not hamper their passage, they are capable of penetrating far into the interior of the country, and, therefore, determine the amount of precipitation, even in such States as Minnesota, Nebraska, North and South Dakota. The moisture-laden winds from the Gulf, as soon as they reach the land and encounter irregularities, are cooled and begin to lose part of their moisture in the form of precipitation.

As long as the air currents are saturated with moisture the slightest cooling or irregularity of the land that causes them to rise will cause precipitation. But as they move inland and become drier the remaining moisture is given off with difficulty and precipitation decreases. The sooner the humid air currents in their passage over land are drained of their moisture, the shorter is the distance from the ocean over which abundant precipitation falls; the longer the moisture is retained in the air currents, the farther into the interior will it be carried and the larger will be the area over which precipitation will be distributed.

If precipitation over land depended only on the amount of water directly brought by the prevailing humid winds from the ocean, the land would be pretty arid and rainfall would be confined to only a narrow belt close to the ocean. Fortunately, not all the water that is precipitated is lost from the air currents; a part runs off into the rivers or percolates into the ground, but a large part of it is again evaporated into the atmosphere. The moisture-laden currents, therefore, upon entering land at first lose the moisture which they obtained directly from the ocean, but in their farther movement into the interior they absorb the evaporation from the land. Hence the farther from the ocean the greater is the part of the air moisture contributed by evaporation from the land. At a certain distance from the ocean practically all of the moisture of the air must consist of the moisture obtained by evaporation from the land. At least it must form a larger part than the water which was obtained directly by evaporation from the oceans.

The vapor brought by the prevailing winds from the ocean is many times turned over or reinvested before it is returned again to the ocean through the rivers.

If we could reduce the surface run-off, and at its expense increase the

evaporation from the land, we would thereby increase the moisture of the passing air currents, and in this way contribute to the precipitation of that region into which the prevailing winds blow. This conclusion is almost axiomatic, and there can be no dispute about it.

"CONTINENTAL" AND "OCEAN" VAPOR

For a long time it has been accepted without any question that all the vapor that is condensed in the form of rain or snow over the land surface is furnished by the evaporation of water from the oceans.

The part which vapor from the ocean plays in the precipitation over land has been altogether exaggerated, and it is hardly possible, therefore, to agree with Professor Moore when he says that "the precipitation over the eastern part of the United States is derived entirely from the evaporation from the Gulf of Mexico and the Atlantic Ocean."

A noted European meteorologist, Professor Bruckner, author of a classical work on the climatic fluctuations, has computed the amount of water evaporated from the ocean surface, land surface, and the amount of water which is returned to the oceans and the land in the form of precipitation. The balance sheet of the circulation of water on the earth's surface is made up as follows:

CIRCULATION OF WATER ON THE EARTH'S SURFACE BALANCE SHEET.

	Cubic miles vapor	Depth, inches	Per cent
A. Entire earth surface (196,911,000 square miles).			
Evaporation from water surfaces....	92,121	29.5	80
Evaporation from land surfaces....................	+23,270	7.5	20
Precipitation on entire earth surface..............	115,391	37.0	100
B. Oceans (141,312,600 square miles).			
Evaporation from oceans	92,121	41.3	100
Amount of ocean vapor carried to the land (net[1])...	−5,997	2.8	7
	86,124	38.5	93
C. Peripheral land area (44,015,400 square miles).			
Ocean vapor (net)................................	5,997	8.7	29
Continental vapor from the peripheral land surface.	+20,871	29.9	100
Precipitation over the peripheral land area.........	26,868	38.6	129
D. Closed interior basins with no drainage to the ocean (11,583,000 square miles).			
Evaporation from closed basins	2,399	13.0	100
Precipitation over closed basins...................	2,399	13.0	100

[1] *I. e.*, the difference between the amount of vapor that escapes from land to the ocean and from the ocean to land.

The continental vapor which is fed from the periphery of the land surface is thus about 21,000 cubic miles. It plays, therefore, an important part in supplying the moisture to the air, even a more important part than the vapor directly fed from the ocean. The peripheral regions of the continents, *i. e.*, the regions tributary to oceans, are capable of supplying *seven-ninths* of the precipitation by evaporation from their own areas. The moisture which is carried by the winds into the interior of vast continents, thousands of miles from the ocean, is almost exclusively due to continental vapors and not to evaporation from the ocean.

In the interior enclosed basins the precipitation and evaporation, as a rule, are equal to each other.

Bruckner figures for entire earth's surface are corroborated also by studies of specific drainage areas. The most interesting study in this connection is that by Professors Francis E. Nipher[3] and George A. Lindsay on the rainfall of the State of Missouri and the discharge of the Mississippi River at St. Louis, Mo., and Carrollton, La. Nipher found that the average discharge of the Mississippi River at St. Louis during the ten years ending December 31, 1887, was 190,800 cubic feet per second. The amount of water falling per second upon the whole State during the same interval was 195,800 cubic feet per second, or equal within two per cent to the discharge of the Mississippi River at St. Louis. If, however, a comparison is made between the total rainfall on the basin draining past St. Louis and the river discharge at this point, it appears that the drainage area of the Mississippi and Missouri rivers above St. Louis is 733,120 square miles, or over ten times the area of Missouri. These figures show what small portion of the total rainfall over the drainage basin of the Mississippi River is led into the rivers and conducted back to the sea. It is evident that by far the larger portion of the precipitation that falls over the drainage basin is evaporated back from the land into the atmosphere, and is not returned to the sea through the medium of drainage. These figures show further that the source of precipitation of the Mississippi drainage is from evaporation over the land and not derived from evaporation over the sea. Mr. Lindsay[4] computed the discharge of the Mississippi River at Carrollton, La., and found that the average for fourteen years was 117

[3] Francis E. Nipher: "Report on Missouri Rainfall, with Averages for Ten Years ending December, 1887." *Transactions of the Academy of Science of St. Louis*, Vol. V., p. 383.

[4] Geo. A. Lindsay: "The Annual Rainfall and Temperature of the United States." *Transactions of the Academy of Science of St. Louis*, June, 1912.

cubic miles per pear, or 545,800 cubic feet per second, which is less than three times the precipitation over the State of Missouri.

The central portion of the United States is distinctly a continental region, particularly the prairie region, which suffers from lack of precipitation. On the other hand, large areas in the South and Southeast suffer from too much humidity because of large swamps, which is caused not only by excessive precipitation, but also by deficient evaporation. Not only the south and southeastern areas suffer from too much water, but also many portions in the North and Northeast, where the evaporation is also very slight. We have, therefore, two extremes on the periphery of the United States: (1) In the States adjoining the Atlantic Ocean and the Gulf of Mexico there is an excess of moisture on the ground, both on account of excessive precipitation and slight evaporation; (2) in the vast interior of the Central United States, on the other hand, there is a deficiency of moisture, both on account of the scant precipitation and of the intense evaporation. Is there not some connection between these two extremes? Is it not possible that changes which take place in one part of this vast region may exert some influence on the condition of the other? We have seen that in the Central States in summer the prevailing westerly and northwesterly winds give way to southerly and southeasterly winds. In other words, in the summer the Central States are under the influence of moist winds, just at the time when the evaporation is the greatest and the forest vegetation is especially active. It seems, therefore, that the amount of moisture evaporated within the more moist region of the United States can influence the conditions of humidity, not only in the States close to the ocean, but also in the region into which the prevailing moist winds flow. The more moisture there is evaporated from the ground in the southern and southeastern portions of the United States, the moister must be the air in the Central States and the more precipitation must fall there.

FOREST THE GREATEST EVAPORATOR OF WATER

What are the sources from which the evaporation on land is the greatest? The evaporation from a moist, bare soil is, on the whole, greater than from a water surface, especially during the warm season of the year when the surface of the soil is heated. A soil with a living vegetative cover loses moisture, both through direct evaporation and absorption by its vegetation, much faster than bare, moist soil and still more than free water surface.

The more developed the vegetative cover, the faster is moisture ex-

tracted from the soil and given off into the air. The forest in this respect is the greatest desiccator of water in the ground.

The latest experiments of Russian agronomists and foresters, corroborated by similar observations in France and Germany, have proved that in level or slightly hilly regions the forest has a desiccating effect upon the ground, causing the water-table to be lower under forest than in the adjoining open fields. Professor Henry, in his recent investigations on the effect of forests upon ground waters in level country, has found that the minimum depression of the water-table produced by the transpiration of forest trees in the Mondon forest, near Luneville, France, amounts to 11.8 inches. With a porosity of the soil strata ranging between 45 and 55 per cent, such depression would correspond to a rainfall of 5.9 inches, which amount to 21,443 cubic feet per acre. This amount of water given off by the forest into the air obviously contributes greatly to the moisture content of the atmosphere above the forest. Dr. Franz R. von Höhnel, of the Austrian forest experiment station at Mariabrunn, carried on observations for a period of three years (1878–1880) upon the amount of water transpired by forests. He found that one acre of oak forest, 115 years old, absorbed in one day from 2,227 to 2,672 gallons of water per acre, which corresponds to a rainfall of from 0.09 to 0.115 inch per day, or 2.9 to 3.9 inches per month. Taking the period of vegetation as five months, the absorption of water would be 158,895 cubic feet, which represents a rainfall for this period of 17.7 inches. This amount of water is given off merely through transpiration from the leaves and does not include the physical evaporation from the surface of twigs, branches, and leaves. These figures, while only approximate, give an idea of the enormous quantities of water given off by forests into the air, which has justly given them the name of the "oceans of the continent."

The most valuable and complete work on the subject is by Otozky, a Russian geologist and soil physicist, which appeared as a publication of the forest experiment stations. Otozky worked up an enormous amount of observations, both his personal and those furnished him by other people, and did not find a single contradictory fact. His conclusion is that the forest, on account of its excessive transpiration, consumes more moisture, all other conditions being equal, than a similar area bare of vegetation or covered with some herbaceous vegetation. The amount of water consumed by forests is nearly equal to the total annual precipitation; in cold and humid regions it is somewhat below this amount, and in warmer and dry regions it is above it.

This enormous amount of moisture given off into the air by the forest, which may be compared to clouds of exhaust steam thrown into the atmosphere, must play an important part in the economy of nature.

If the present area occupied by forests in the Atlantic plain and the Appalachian region were instead occupied by a large body of water, no meteorologist would hesitate for a moment to admit that the water surface has a perceptible influence upon the humidity of the Central States and prairie region. Should not, therefore, forests which give off into the atmosphere much larger quantities of moisture than free water surface have at least a similar influence upon the regions into which the prevailing air currents flow?

If the southern and southeastern winds, in their passage toward the north, northwest, and northeast, in the spring and summer, did not encounter the vast forest areas bordering the shores of the Gulf of Mexico and the Atlantic coast and those of the southern Appalachian, and, therefore, were not enriched with enormous quantities of moisture given off by them, the precipitation in the Central States and the prairie region would undoubtedly be much smaller than it is now.

What would be the effect of complete or even partial destruction of forests in the Atlantic plain and in the southern Appalachian Mountains upon the humidity of the continental portion of the United States? As the mean temperature in the eastern part of the United States drops rapidly from south to north, the moisture-laden air currents upon entering land would be cooled off and rapidly drained of their moisture within a comparatively short distance from the ocean. The sandy soil, which is so characteristic of the southern pine belt of the Gulf and south Atlantic States, would rapidly absorb the rain which would percolate into the ground, without returning much of it into the atmosphere. The rain falling upon the slopes of the mountains would rapidly run off into streams. While direct evaporation from the ground not sheltered by forest cover may become greater, yet the more rapid run-off and the absence of transpiration by trees would necessarily reduce the total amount of water evaporated into the atmosphere. The land, were it even taken up for agriculture, would not return such large quantities of rain into the atmosphere as the forests did. The inevitable result would be that less moisture would be carried by the prevailing winds into the interior of the country, and therefore less precipitation would occur there. Such is the influence of forests in a level or a hilly country.

Whether forests in the mountains have the same effect as forests in level countries upon the precipitation of the regions into which the

prevailing winds that pass over them blow is difficult to determine. The problem is more complicated for the reason that high mountain chains exert an influence upon the direction of the winds, not only by presenting a mechanical obstruction to the free passage of the air, but also on account of the difference in the heating of the different slopes.

A moist current of air in passing over a mountain chain undergoes several changes. It is known that the air in ascending becomes cooler. The temperature of not fully saturated air decreases 1° F. for every 182 feet of ascension. In ascending the mountain slope the water-holding capacity of the air decreases until the saturation point is reached, and fogs, clouds, and precipitation begin to form. The further cooling of the air is counteracted to some extent by the heat that is given in the process of the condensation of vapor. This further cooling, therefore, proceeds only at the rate of about 0.5° F. for every 182 feet of ascension, or only half as much as when the air is dry. After the air current has passed the crest of the mountain and lost an amount of moisture corresponding to the temperature which it had at the time of passage, it descends on the leeward side and becomes heated.

In its descent it absorbs the fogs and clouds. In this process it consumes some heat. The further heating goes on at the rate of 1° F. for every 182 feet of descent. The more moisture there is extracted on the windward side of the slope, the greater is the temperature of the air on the leeward side.

If, for instance, an air current before ascending had a temperature of 50° F. at a barometric pressure of 30 inches, and the crest over which it passed was 9,900 feet high, then, on the leeward side at the same altitude at which it began to ascend, it would not have a temperature of 50° F., but of 77° F. at a relative humidity of 21 per cent. At other ascensions by the same current of air, the same changes would take place. But new precipitation, as a rule, begins on the next chain of mountains only at an altitude equal to that of the crest of the previous mountain chain over which the current of air has passed.

Professor Mayr[5] has shown that wherever there are several parallel chains of mountains perpendicular to the moist air current, such as are found on the Pacific coast, of which each one is higher than the previous one, the forest appears in each consecutive mountain chain only from an altitude equal to the altitude of the top of the preceding chain over which the air current has passed. Between the mountain chains there remain treeless, dry valleys. This is strikingly observed in the Pacific coast and Rocky Mountains, as well as in Caucasus and Turkestan.

[5] "Waldungen von Nord Amerika."

As a rule, the moist air currents, in passing over wooded slopes, being chilled, deposit most of their precipitation on the windward side. It is only in exceptional cases, such as when the air that passes over the wooded slopes is not fully saturated, or when warm currents rise from below, that the air current, instead of depositing moisture, becomes enriched with moisture and carries it over the crest to the regions lying farther on its way.

This may occur on southern slopes, which are apt to become warm. The influence of wooded, windward slopes upon the humidity of the regions lying to the leeward side of the mountain chains, therefore, varies. It is apparent, however, that, while the forests in the mountains at right angles to prevailing moist winds have a marked influence upon local precipitation, their influence upon the humidity of regions lying to the leeward of them cannot, on the whole, be very great.

CONCLUSIONS

If the effect of mountainous forests upon the precipitation of regions lying in the lee of them is not entirely clear to us, the effect of forests in wide plains of continents, especially in the path of moist winds, cannot be doubted. By increasing the evaporation from the land at the expense of surface run-offs they enrich with moisture the passing air currents, and in this way help to carry it in larger quantities into the interior of continents. The destruction of such forests, especially if it leaves the ground bare or partly covered with only weak vegetation which does not transpire large quantities of water, must inevitably affect the climate, not so much the climate of the region in which the destruction took place, but the drier regions into which the prevailing air currents flow.

I realize, of course, that direct proof of this climatic influence quantatively expressed is still lacking. It will take many decades before direct observations of such a character will be secured. If, however, the premises upon which the discussion rests, namely, that the precipitation of the eastern half of the United States is intimately connected with the prevailing south winds, that evaporation from land contributes more to the precipitation over land than evaporation from the ocean, that forests evaporate more water than free water surface, or any other vegetation, then forests in the path of prevailing winds must necessarily act as distributors of precipitation over wide continents.

What practical deductions can be made from these facts?

1. Forests must be protected not so much in localities which already suffer from lack of moisture as in regions which lie in the path of

prevailing winds and are still abundantly supplied both with ground water and precipitation. In the dry regions large bodies of forests may have the opposite effect upon the available water supply. There only forests growing along rivers may contribute to the humidity of the region. There rows of trees or wind-breaks surrounding fields and orchards, by preventing the drifting of the snow and decreasing the activity of the wind, will act more as conservers of moisture in the soil than solid bodies of timber. Therefore, the care with which forests should be protected in the eastern half of the United States must increase from north to south and from west to east.

2. In the Atlantic plain and southern Appalachians, which are the gateway for the prevailing winds from the Gulf of Mexico and the Atlantic Ocean, forests must be especially maintained.

(*a*) On moist soils, provided the excess of water or the substances contained in it do not prevent their development, because the moister the soil on which forests grow the more moisture they evaporate. For this reason swamps, since they contribute less to the moisture contents of the air than crops or forests and lose considerable water by surface run-off, must be drained, as by doing this an increase of the evaporation at the expense of surface run-off may be secured.

(*b*) On sandy soils. Forests on sandy soils readily absorb water through the roots and evaporate it into the atmosphere. Denuded of forest cover, sandy soils readily absorb rain-water which percolates into the ground and often reaches the sea by underground channels without being returned to the atmosphere.

(*c*) On steep slopes and rocky places. The removal of forests on such places inevitably leads to an increase in the surface run-off and to a corresponding decrease in local evaporation.

3. If clearing of the forest is a necessity it should be done only under condition that the cleared land is to be devoted to intense cultivation, as after forests crops contribute most to the moisture of the air. The highest organic production, therefore, is in harmony with the safeguarding of the humidity in the regions which lie in the path of the prevailing winds. Cleared land that becomes waste or poor pastures, or grows up to weak vegetation, means so much evaporation lost to the passing air currents.

The effect of forests upon climate, if viewed as a local influence, must necessarily be insignificant. First, we must not forget that whenever we compare a forest with an open field adjoining it, the open field itself is under the influence of the forest and cannot give a proper conception of the true effect of the forest.

Such a meteorological authority as Lorenz Liburnau, at the end of his monumental work on "The Results of Forest Meteorological Observations," remarks that his data and conclusions apply only to the influence which the forest exerts while it exists, but do not extend to conditions which may arise upon its complete destruction. "If, for instance, according to our observations in the Carpathian foothills, it appears that the influence of the forest upon the neighboring country is only insignificant, this does not indicate that a complete destruction of all the existing forests will produce here also only insignificant climatic changes. Very likely that, if the forest were completely destroyed, the difference would be much greater than the difference that exists now between the climate of the forest and its neighboring areas."

Local observations, no matter how accurately and minutely carried out, cannot lead us to the solution of the problem. The method of attack itself is wrong. It is only by approaching the problem from a much broader standpoint, by rising mentally to a height which opens wide perspectives both to the distant shores of the Gulf of Mexico and the Atlantic Ocean and to the most interior portions of the continent; only by following the moist south winds on their way from the Gulf through the gateway of the North American continent, the Atlantic plain to the prairie region; by considering how many times the moisture carried by the wind is dropped in the form of precipitation and raised again as evaporation; by studying the part which the vegetative cover plays in this circulation of water on the land, especially the dense coniferous forests, that we can grasp the problem in its true light.

THE LUMBERMEN AND WOOD-USING INDUSTRIES*

BY McGARVEY CLINE

Contributed

In 1909 the census reports show that the sawmills of the United States produced 44,509,000,000 board feet of lumber. Approximately 73 per cent of this amount was made up of five species, viz., yellow pine, Douglas fir, oak, white pine, and hemlock. Where and how this enormous quantity of material is consumed has been and is still largely a matter of surmise. An investigation, however, which is being made by the Forest Service has progressed far enough to warrant some tentative estimates on the annual requirements of the different wood-using industries. With this paper are presented several tables based on a study of the wood-using industries of 20 States. From these tables certain deductions may be drawn.

Table 1 shows the amount of wood in millions of board feet that is consumed by 51 different industries in the 20 States upon which the report is based. Eighty-four per cent of the material reported was consumed by 11 industries. For these 11 industries I have prepared an estimate of the total consumption of lumber in the United States, basing it on the capital invested in the industries as reported by the Bureau of the Census. According to this estimate, which I think is approximately correct, the lumber cut is distributed as follows:

	Per cent total lumber cut	Millions of board feet
(1) Planing mill products, including sash, doors, and general mill-work	29.70	13,250.00
(2) Boxes and crating	10.00	4,448.00
(3) Car construction	4.48	1,957.10
(4) Furniture	3.02	1,348.16
(5) Vehicles	1.97	877.31
(6) Agricultural implements	.78	350.67
(7) Musical instruments	.61	273.48
(8) Woodenware	.51	228.16
(9) Ship and boat building	.43	192.63
(10) Trunks and valises	.21	94.98
(11) Handles	.63	281.64
(12) Miscellaneous industries	12.30	5,470.00
(13) Export	6.74	3,000.00
(14) Sawed ties	2.28	1,017.00
(15) Rough lumber and structural timbers	26.32	11,750.00

* Prepared for the meeting of the National Lumber Manufacturers' Association held in Cincinnati, Ohio, May 8, 1912.

BUILDING TRADES AND GENERAL CONSTRUCTION

If we assume that practically all of the planing-mill products go into the building trades, these estimates indicate that 56 per cent of the entire lumber production, or 25 billion board feet, goes into building and general construction work. This amount is made up as follows:

80 per cent total yellow pine manufactured	13.0	billion
80 per cent total Douglas fir manufactured	3.9	"
90 per cent total hemlock manufactured	2.7	"
Cypress, white pine, redwood, oak, and other hardwoods	5.4	"

It seems, therefore, that fully 50 per cent of the entire lumber produced has to be sold in competition with cement, brick, tile, etc.

BOXES AND CRATING

It seems from the figures here presented that the various estimates of the amount of lumber consumed by the box industry which have appeared from time to time have been much too high. Ten per cent of the total lumber production, or approximately 4,448 million board feet, is used in the manufacture of boxes and crates. This amount is made up approximately as follows:

8.9 per cent total yellow pine manufactured, or	1,440	million	b. f.
28.0 per cent total white pine manufactured, or	1,097	"	"
62.0 per cent total red gum manufactured, or	438	"	"
8.2 per cent total hemlock manufactured, or	252	"	"
6.4 per cent total spruce manufactured, or	112	"	"
15.7 per cent total yellow poplar	135	"	"
Other species mentioned in Table 3	974	"	"

Thus 10 per cent of the total lumber manufactured has to compete with fiber board and veneer. Such competition is becoming more and more acute as the demands of shippers and transportation companies for lighter and at the same time stronger boxes increase. Tests made at the Forest Products Laboratory show that the ordinary nailed box is inferior in many respects to improved types that are being introduced, and it is my personal opinion that the ordinary type of wooden box will lose its present position of leadership among shipping containers unless its manufacturers are able to overcome some of its inherent defects.

CAR CONSTRUCTION

Approximately 4.5 per cent of the total lumber manufactured, or 1,955 million board feet, is used in the construction of cars. This amount is made up as follows:

7.27 per cent total yellow pine manufactured	1,183.3	million	b. f.
3.4 per cent total Douglas fir manufactured	168.0	"	"
6.1 per cent total oak manufactured	271.8	"	"
6.1 per cent total yellow poplar manufactured	52.3	"	"
Other species as indicated in Table 3	279.6	"	"

Lumber used in car construction is coming into competition with steel underframing and steel bodies. The competition with steel for underframes and for passenger coaches is becoming more and more active, and unless there is a change in policy on the part of the railroads wood as a car material may soon be limited to use in box cars.

FURNITURE

Three per cent of the total lumber manufactured is consumed by the furniture industry. This industry also imports considerable amounts of mahogany and other cabinet woods. The 1,348,000,000 board feet of domestic material consumed is made up as follows:

14.0 per cent of total oak manufactured	629	million	b. f.
10.0 per cent of total maple manufactured	112	"	"
24.6 per cent of total birch manufactured	111	"	"
13.9 per cent of total red gum manufactured	98	"	"
7.5 per cent of total yellow poplar manufactured	65	"	"
6.7 per cent of total basswood manufactured	27	"	"
All other species	306	"	"

It is very noticeable to what a small extent the softwoods enter this industry. Steel is being substituted for wood to a moderate extent in the manufacture of certain classes of office furniture, and iron and brass are being largely used for beds, but in general the furniture industry offers an excellent market for high-grade hardwoods.

VEHICLES AND VEHICLE PARTS

Two per cent of the total lumber manufactured, or 877.3 million board feet, is used in the manufacture of vehicles. It is made up principally of oak, yellow poplar, maple, red gum, and other species mentioned in Table 3. Steel is being substituted for wood to a certain extent in this industry, but such substitution is doubtless due more to the difficulty the manufacturer encounters in securing sufficient wood of the quality desired than it is to the superiority of steel.

The remainder of the 51 industries mentioned in Table 1 consume relatively small quantities of material, and in them the competition of wood with other materials is of minor importance with respect to its effect upon the general lumber situation.

DISTRIBUTION OF SPECIES

Table 3 is of particular interest in that it shows the distribution of our most important species among the wood-using industries. A study of it brings out very clearly some fundamental differences in the problem of marketing softwoods and hardwoods. It appears that fully 91 per cent of the yellow-pine manufactured, 89 per cent of the Douglas fir, and 98 per cent of the hemlock are consumed in building and construction work and in the manufacture of boxes. Large proportions of the cypress, white pine, and other conifers also enter these industries. In the building trades and in the box industry the cost of raw materials constitutes a comparatively large proportion of the cost of the finished products; therefore, any rise in the price of raw materials has a proportionately large effect on the cost of the finished article to the consumer. Lumber has long been the material from which a house of any given size and finish could be built at the least cost to the builder, and its wide use as a building material in this country has undoubtedly been more due to this cause than to its merits or demerits as a building material. In the case of residences and other small houses fire risk and durability become strong arguments in favor of substitutes only when the retail price of lumber is such that the cost of a frame house equals or is only slightly less than an equivalent house built of brick, tile, or other materials. The manufacturers of lumber, who are largely dependent upon the building trades for their markets, should recognize this fact and devise ways and means of so regulating their selling costs that lumber will continue to be the material from which a satisfactory home can be built at a minimum cost to the builder.

The manufacturers of yellow pine in particular, and of Douglas fir also, have excellent opportunities to divert much of their low-grade lumber into paper, turpentine, alcohol, and other by-products. The writer touched on this subject in a paper presented at the last meeting of the Yellow Pine Manufacturers' Association and urged the importance of such developments to the owners of yellow-pine stumpage.

The manufacturers of hardwoods are facing a much less difficult situation. Their products are used in a large number of different industries in which the cost of raw material is only a small proportion of the cost of the finished article. In these industries, viz., furniture, vehicles, handles, and many others of minor importance, wood is used because it has properties which make it peculiarly fit for the purpose that it serves and not principally because it is the cheapest raw material

suitable to the needs of the manufacturers. This diversity of use offers an excellent opportunity to the manufacturers of hardwoods to work up their logs not only into the standard forms of lumber, but into numerous sizes of small-dimension stock. It seems to the writer that it would be to the mutual interest of hardwood manufacturers and consumers to study the problem of standardizing small-dimension stock of different species. Such standardization should result in greater profits to the lumber manufacturer through closer utilization of his logs, and in cheaper material to the consumer.

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MICROSCOPIC STRUCTURE OF WOODS IN RELATION TO PROPERTIES AND USES

BY ELOISE GERRY

Delivered before the Society November 21, 1912

I. INTRODUCTION

With the organization and development of the study of forest products the advantages of a more intimate knowledge of wood substance have been made very clear. By means of the microscope the minute physical structure and, through microchemistry, the chemical composition of wood, have become promising fields of research.

Wood is an organic substance. It is the framework produced by the living protoplasm. Long after the vital activity of the cells composing it has ceased, as, for instance, in heart-wood, the cell walls act as a mechanical support for the growing portions of the tree; namely, the crown of leaves and the outer layers of the trunk, which include the inner bark, the cambium or region of dividing cells, and the young or sap wood, where the new-wood elements are developing and differentiating. It is this highly organized framework, which once served in the vital processes of conduction, storage, etc., in the tree, which is utilized as an economic material in such a multiplicity of ways by more than fifty different industries.

In construction, wood competes with tile, brick, cement, steel, and many other inorganic compounds of relatively homogeneous character. The differences in the nature of these two classes of materials are apparent when they are compared under the microscope. Plate I, figure 1, illustrates a cross-section of a steel ball, cut and polished to show its structure. The ball, according to its chemical composition, was described as a "common steel."* In marked contrast to this is the structure of a piece of wood shown at the same magnification in Plate I, figure 2. This also illustrates the differences in structure between wood formed in the summer and autumn, which appears at the top of the figure, and the spring wood or early growth of the year, which appears below. The difference in the size and thickness of the walls of

* In "Proceedings of the International Association for Testing Materials." Sixth Congress, New York, page 2, 1912, in volume II, No. 13, from which the illustration was copied.

the tube-like cells, which are the "fibers" of the paper trade, but are known botanically as tracheids, is evident in this cross-section.

The wood shown in figure 2 is a piece of short-leaf pine, ***Pinus** echinata.* Not only is ***pine*** structurally complex; so also are other woods. Each genus, or group of species, varies in a more or less marked way from all the other genera. Pine, moreover, is a relatively simple wood as compared, for example, with oak. Furthermore, the structural elements in the individuals of a species, even, may vary; for instance, as in the proportion of spring and summer wood, the degree of lignification, etc., according to the growth conditions prevailing at the time of their formation, adding still other factors that must be taken into consideration in selecting and using wood.

In the year 1909 about twenty-five billion board feet of wood, chiefly yellow pine, Douglas fir, oak, and white pine, went into building and general construction in the United States, in competition with the inorganic materials already mentioned.* The men who worked with the wood had a relatively small conception of the material they were using. Obviously, efficient utilization depends upon definite knowledge of this. The principles of "scientific management" can undoubtedly be applied with benefit here as in other industries.

The layman speaks of a wooden house or a wooden cart or carriage. Let us consider for a moment the number of different kinds of wood used in the construction of *one* vehicle, and the appearance of these woods when seen under the microscope. Plate II shows cross-sections, at the same magnification, of six of the more important woods used in wagon construction.

Hickory and white oak are very important wagon woods, and are used for several different parts, as, for example, frames, spokes, poles, shafts, and also hubs and felloes. Figure 1 is a photomicrograph of a "commercial" white oak. This wood has long been famed and prized for its strength and durability. The dense masses of fibers noticeable in the upper portion of the one complete annual ring here shown are responsible for the strength of the wood. This is a typical "ring-porous" wood; that is, all the large pores, vessels, or sap channels, are grouped in a limited area early in the year's growth. These are open and function in sap conduction when they are first formed, but after a period of activity are closed in this wood, and, in others to be discussed later, by thin-walled, sack-like growths called tyloses, which intrude from the

* McGarvey Cline: "The Lumbermen and Wood-using Industries." Paper presented at the meeting of the National Lumber Manufacturers' Association at Cincinnati, Ohio, May 8, 1912.

surrounding cells. A typical full development of these "filling cells" called *tyloses* is apparent in all the large vessels in figure 1.

Plate II, figure 2, shows a piece of hickory with three complete annual rings extending horizontally across the field. Tyloses, also fully developed, appear in this section, which was cut from the outer rings of the sap-wood of the tree. This wood is particularly interesting because it combines strength, elasticity, and toughness, and is moreover a distinctly American wood.

The bodies of wagons are often made of basswood, cottonwood, or the yellow poplar, which is generally known as the tulip tree, *Liriodendron tulipifera.* This last-mentioned wood is also used for seats and panels. It is highly prized because it takes such an even finish when painted. It is said to appear nearly as smooth as metal, and not to dent as readily. Tulip, Plate II, figure 4, in contrast to the preceding woods, is typically "diffuse porous" in structure. In the wide annual ring illustrated the pores are scattered with considerable uniformity throughout both the spring and summer wood. The specific instance of the different uses to which tulip and oak are applied in a carriage is a good example of the application along general lines of the knowledge of structure and properties in relation to uses.

Other woods used for the bodies of farm wagons, where fine finish is not applied, are white, long-leaf, and loblolly pines, and sometimes cypress. These woods belong to the "non-porous" group, which is illustrated by short-leaf pine in Plate III at a considerably higher magnification than that used in Plate II. These woods derive their name from the fact that their "fibers" or tracheids are not open channels, like the pores in oak or tulip, but are, from the time of their formation, separated from one another by walls.

Elm, Plate II, figure 5, and locust are also used for hubs. Beech is used for large felloes and ash for seats. This latter wood, Plate II, figure 3, serves to illustrate the appearance of a ring-porous wood without tyloses. The open pores here give a forceful contrast to the condition in white oak and hickory.

A wood valued particularly for the construction of certain parts of a wagon is the osage orange, *Toxylon pomiferum.* This wood is also notable because of its very marked development of tyloses closing the vessels. Moreover, in this case also the section illustrated is cut from the outer sap-wood, a fact which further bears upon the distribution and significance of tyloses. Osage orange is dense and strong. Per cubic foot it weighs 48.21 pounds; white oak weighs 46.35. In strength (modulus of rupture) it exceeds white oak 26 per cent, while in stiff-

ness (modulus of elasticity) osage orange is 2 per cent above white oak. The wood swells and shrinks but little under climatic changes, and wagon wheels with osage rims give long service under conditions fatal to an ordinary wagon. The impact and concussion, such as is produced on rocky roads, however, splinters the wood; but for long, hot seasons and dry roads it gives excellent service. Tires do not work loose, and often wear out without being reset* (Plate II, figure 6).

From this brief analysis of the kinds of wood used in vehicle construction alone, the relation of the structure to the uses to which the woods are applied is evident. That wood is not a homogeneous material has been shown beyond question by Plates II and III.

The importance of *identifying* woods by the differences in microscopic structure combined in many cases with other characters, as fruit and leaves—for wood structure is very conservative and specific differences are often very slight—has long been recognized, and many systems have been devised for the purpose. More recent, however, is the attempt to study the effects of differences or similarities in structure on properties and uses. This study has opened a field of such interest, and is so rich in opportunity, that prophecy and desire have outstripped each other in detailing the possible application of investigations of this nature to practical ends. Consequently, some disappointment has been experienced with the realization that the study is not productive of "glittering generalities." This, however, is in keeping with the variations and irregularities of the material studied. The obstacles presented are nevertheless not necessarily insurmountable in this search after fundamental principles.

In order to undertake investigations of the relations existing between structure and properties and uses, a thorough knowledge of plant anatomy is essential. A sufficient understanding of physics and chemistry to enable the worker to apply the principles and new discoveries of these sciences, when possible, to his work with wood is invaluable. Furthermore, the power of mind which we express by the words experience and judgment, which comes from intimate and prolonged relations with wood-using industries and work in the forest, cannot be too highly estimated. Technique in manipulation, in order that the section studied with the microscope may present, without distortion or misrepresentation, the conditions in the block from which it was cut, is of the utmost importance. The more perfectly the preparation studied micro-

* Hu Maxwell: "Osage for Wagons and Other Purposes."

scopically is made, the more satisfying and fundamentally true are the resulting observations. When the existing conditions can be made visible to *all* by the aid of photomicrography, so much more far-reaching can the results of this phase of the study of forest products become.

II. THE METHOD

A brief summary of the means used to approximate the ideal method of study may be given here, as much of the time since this branch of work has been undertaken in the section of timber physics at the Forest Products Laboratory has been devoted to the adaptation, perfection, and exercise of methods.

Material.

The laboratory collection of American commercial woods obtained for tests of all kinds and exhibition purposes has formed the basis of a reference collection of microscopic slides of wood. Strips cut a square inch in end section, extending from the bark through the heart of the tree, were used in the preparation of slides. One of these is shown in Plate IV, figure 1, with the microtome. Small blocks from these, one in the sap-wood next the bark, one midway in the heart-wood, and one at the very center of the tree with the pith, were taken from each strip and treated with hydrofluoric acid, when necessary, for the purpose of dissolving out the mineral matter in the wood in order to insure easy cutting and smooth, even sections.

The Microtome.

The blocks were then sectioned on the Jung Thoma sliding microtome, Plate IV, figure 1. The instrument is very well adapted for this purpose. Certain improvements in the rigidity and ease of orientation of the carriers have been made by Prof. R. B. Thompson, of Toronto University, and Mr. H. W. Spence and are now employed. The razors used are of especially hardened steel, sharpened to a keen, smooth edge, and kept in order by use of oil and water stones and a Jung four-sided strop. With this instrument it is possible to cut cross-sections, with a square inch of surface, less than one five-thousandth of an inch (five micromillimeters) in thickness from even such a hard wood as live oak.

Sections are cut from each of the three blocks in three planes. The different planes are illustrated by the three photomicrographs of short-leaf pine shown at the same magnification in Plate III. The cross-section, figure 1, shows the junction of two annual rings. The summer wood, with a large, open resin canal, surrounded by thin-walled cells,

called the epithelial cells, is conspicuous. The medullary rays run horizontally across the field. The middle lamella and the different thickening layers, which the cells lay down during growth, are very clearly shown here. In the radial or quartered face, figure 2, the longitudinal view of the elements, at right angles to that just shown, gives a clear idea of the "fibers" or tracheids. The tapering ends of these are visible; also the bordered pits or thin places which appear like little circles in the cell wall. The closing membranes of these are permeable to water. Traversing the right end of the figure is a medullary ray showing the characteristic toothed or dentate ray tracheids of the hard pines.

The tangential face shown in figure 3 is also a longitudinal view, but is cut at right angles to the radial just shown. The tracheids, their tapering ends, the pits in profile, linear medullary rays, and one fusiform ray with a resin canal, are here visible.

In this way the sections are selected in these three planes from all the different specimens, the purpose being to show the distinctive features of each species.

The Sections.

The sections are stained and mounted with the greatest care to guard against air bubbles, dirt, and foreign matter. They are dried under weights to insure flatness, which is a very important quality, as the depth of focus of the microscopic lenses is limited. In order to produce good photomicrographs it is essential that all the parts of the field should be in focus simultaneously. All the slides here reproduced are taken from photomicrographs of sections prepared in this way. The general methods above described for use with hard tissues, such as wood, were developed and perfected by Dr. E. C. Jeffrey, of Harvard University, and have been only slightly modified to meet the demands of this work. The technique of preparing the sections requires a high degree of skill; its importance cannot be overemphasized, since subsequent observations, as well as the photomicrographs which record them, are dependent upon slides produced.

The Photomicrographs.

The apparatus used for making the photomicrographs is a Bausch and Lomb balopticon. It is equipped with a Zeiss microscope and the source of light is an electric arc. The apparatus includes the lamp case, cooling cell, condensing lens system, holder for the color screens, and the microscope, which is equipped with a full battery of lenses, including

Zeiss tessars, apochromats, achromats, and compensating eyepieces. A light-tight sleeve connects the microscope and camera, the shutter of which occupies the same position as the human eye in ordinary microscope use. The magnification can be controlled by the lenses and by the lengthening and shortening of the long, horizontally mounted bellows. The use of color screens is of the greatest possible assistance in producing photomicrographs showing the different kinds of tissue as differentiated through staining. This phase, as well as other special features of this work, has been developed with marked success by Dr. M. E. Diemer, chemist and expert photographer, who kindly assisted in the preparation of the photomicrographs presented in the accompanying plates.

The sections and photomicrographs are of the utmost assistance in the study of special problems. Dry wood, creosoted, green, shrunken, compressed, distorted, and decayed wood have all been cut for microscopic examination. Plate IV, figure 3, for instance, shows how fungus mycelium travels from the rays into and through the wood elements. The way in which the vessel segments which unite to form the long sap-conducting tubes of the tree are connected is also illustrated. In red gum, *Liquidambar styraciflua*, these openings are not so completely developed as they are in aspen, *Populus tremuloides*, and, instead of a round hole, a grating, such as is shown in Plate I, figure 4, connects adjacent vessel segments. In pine the corresponding structures, the bordered pits, illustrated at a high magnification in Plate I, figure 3, are thin places in the cell wall, but are closed by a membrane. They permit a relatively slow transfusion of water. This contrast in structure between pine and aspen and gum shows why the latter are called porous and the former non-porous. New problems sometimes require fresh adaptations of the methods. Smooth surfaces of blocks are sometimes used, for example, instead of sections, and these are then photographed by reflected instead of transmitted light. The use of serial sections for studying the development of structures or conditions, such as extent of penetration of creosote or of decay, has also been found helpful. The formation and later development of resin canals have been studied in this way by means of a series of sections cut, beginning at the inner bark and following the same canals through an inch or more of wood, which distance frequently includes several annual rings.

III. THE PURPOSE

It is the purpose of this work to find out *facts* about the relation of the microscopically observed structure of the wood and its properties and uses. That such a relation exists is not questioned. The detailed knowledge of this relation has extensive practical application. Either positive or negative evidence will be of value in solving the problems involved. People who know little of the subject either think nothing about it or tend to formulate weird concepts often as vague and misleading as those of the ancient alchemists. For either of these classes of people a clear, readable statement of experimentally proven relations, not theories alone, no matter how carefully the latter may have been constructed, should certainly be of value. In brief, then, the object of these microscopic investigations is service; service to outsiders who may send in their problems and receive in return a careful consideration of their questions and all the information available; and also coöperation with the men in the Forest Service, since coöperation between field and laboratory studies means a gain for both. This type of service is rendered directly, so far as possible, whenever the need arises. In addition to this, indirect service is offered through the investigation of special problems of sufficient importance to demand considerable time and concentration of effort. Practical men are urged to send in their problems that the information most generally needed may receive due attention in the preparation of working plans. For the study and illustration of problems in wood structure the equipment in the Forest Products Laboratory perfected as the result of experience and experiments is probably unexcelled.

IV. THE RESULTS

First and foremost of the results so far accomplished is the reference collection of microscopic slides of the actual wood and of photomicrographs of these, the preparation of both of which has been previously described. The slide collection consists of more than 2,000 slides from about 150 specimens. Among these are slides showing interesting abnormalities, such as the effects of decay above illustrated, and also especially thin sections prepared for high-power photomicrography.

The collection of photomicrographs is made up of two series, the respective members of which are directly comparable. The first series is made up of cross, radial, and tangential section photomicrographs of the different species at a magnification of 50 diameters on 6½ by 8½ plates. All the cross-sections show at least one annual ring with its character-

istic spring and summer wood. These photographs, if estimated by the amount that they are used in the study of special problems, certainly form a very important part of the work thus far accomplished. Pictures are a more successful means of exposition than words in a field of this nature. Hence the clearness, uniformity for comparative purposes, and range of species covered have proved to be of constant interest and value, not only to inquiring visitors, but to members of the different laboratory sections, Forest Service men in the field, railroad men, men interested in the artificial preservative treatments of wood, manufacturers, and teachers of engineering and wood structure. The second series supplements the first. The first shows a large field at a sufficiently low magnification to be readily comparable with a block of wood viewed with a hand lens. In the second series the magnification is 250 diameters. This is sufficient to show the different thickening layers in the cell walls of a conifer, for example. Plate I, figure 2, is reproduced at about this magnification.

Another line of work which has occupied a large amount of time is the preparation, micro-examination, and photomicrographing of different kinds of wood pulp. Much of this work is carried on in coöperation with the laboratory at Wausau, Wisconsin. About 1,000 slides of ground-wood pulps are now on file. The photomicrographs of slides made from the experimental runs of ground-wood pulps are considered as valuable criteria and are preserved as permanent records of the experiments and tests.

In connection with the experiments in the laboratory section of paper and pulp, micro-examinations of aspen, eucalyptus, and redwood pulps, prepared under various cooking conditions, have been made. It was found that undercooking and overcooking could be detected readily and that the actual strength corresponded with differences which could be detected in the microscopic appearance of the fibers. Plate IV, figure 4, is a photomicrograph of aspen pulp. One of the characteristic vessel segments occupies the center of the field.

The special problems so far studied are two in number. The first relates to the distribution in general, and in the *sap-wood* in particular, of tyloses, the sack-like cells previously described. In the hardwoods these cells grow into the large vessel cavities after the internal pressure, due probably to sap flow, has ceased. It is because of their presence strongly developed, as has been shown in osage orange and white oak, Plate II, that the latter wood is successfully used for tight cooperage, while red oak, which lacks these cells almost entirely, cannot be so utilized.

The results of this study have been assembled in form for publication. They include a table of observations on 176 specimens of American hardwoods, showing the degree of development of tyloses. General statements hitherto have, for the most part, been to the effect that tyloses are not formed normally until the annual growth rings have reached a considerable age; that is, that they do not occur in the sap-wood or the outer growth rings of the tree. As a matter of fact, however, these studies show that tyloses occur in the sap-wood of at least twenty-five species of hardwoods (practically wherever they were found in the heart-wood), and are generally very well developed even in the outermost rings next the bark, as has been shown in hickory and in osage orange, in Plate II. Woods where tyloses occur are, for the most part, with the exception of hickory, exceptionally durable woods.

It has been shown conclusively also that tyloses check creosote penetration. In spite of this a wood may be thoroughly penetrated by creosote, even if its vessels are closed with tyloses. In Plate I, figure 6, the radial surface of a creosoted hickory block shows such a condition. A vessel filled with entirely uncolored tyloses is shown extending vertically through the left center of the figure. The thorough penetration of the surrounding wood, which was even more apparent in the block than in the picture, is evident from the blackness of the longitudinal elements. The rays here also appear uncolored. They, in fact, treated little better than the tyloses in this piece.

Tyloses act, a carpenter would say, as a natural filler and, as such, are a factor in finishing wood. The network of cells, as shown in Plate I, figure 6, aids both in catching and in holding the filler used in finishing. This is again in marked contrast to red oak, where such a vessel as is shown in Plate I, figure 6, would appear like an open groove. This study, outside of the working up of the extensive German literature on the subject, was carried on at the same time as the routine slide making. The different blocks from the sap and heart wood of each species were invaluable for this study, as well as for other comparisons of conditions in these two regions which are as yet untabulated. This study also brought to light the fact that many of the *vertical* resin canals in pine are *not* closed with tyloses or otherwise throughout their *entire* length. This is also contrary to the generally accepted statements on this subject and has a definite bearing on the studies of creosote penetrance which have been the subject of the more recent experiments.

The influence of the structure of wood on the penetration of creosote is one of the most baffling, contradictory, and, at the same time, intensely interesting problems. Definite data on the subject are de-

manded. The phase of the problem now before us has resolved itself into the question of how creosote passes from one tracheid to another in a coniferous wood. This question may be divided into three parts: Does the penetration take place—

(1) Through the cell-wall substance;

(2) Through the structural modifications of the cell wall; *i. e.*, pits; or

(3) Through actual openings in the cell wall; *i. e.*, checks or "slits" or the rupture of pit membranes?

In spite of many experiments, it is as yet impossible to answer finally any of these questions. That we have reached the point where it is possible to formulate them is more significant than would at first appear.

The first microscopical studies of creosote penetration were made on creosoted wood *after* treatment. In this way the final location of the creosote was observed. But the opportunities for numerous and conflicting theories as to how the creosote arrived in the regions occupied increased the already large amount of perplexing discussion on the subject. It was only when experiments for watching the actual progress of the incoming creosote under the microscope were carried out that certain facts became evident. The results here cited are in the nature of preliminary work, and are mostly confined to loblolly pine summer wood. Other species were tested, but with the apparatus used and the low-pressure compressed air this species was found to be the most satisfactory. The flow of the oil was distinctly visible in the tracheids just below the surface of the block. Carefully split and smooth-surfaced pencils of wood clamped to the microscope stage were used for this purpose. Although movement was visible, the relative roughness of the surface prevented the detection of the point where the creosote passed from one tracheid to another. The fact that creosote sometimes escaped through the cut ends of tracheids and flooded the outer surface of the block, thus obscuring what was happening deeper within the wood, also delayed the work.

Nevertheless, columns of creosote were repeatedly seen to flow along the tracheid lumena, to be checked in their course, and, after a barely appreciable length of time, to appear in other tracheids further on. It is certain that penetration is greatest in the longitudinal direction. It has been estimated that for conifers it is 20 to 120 times as great as in the radial and tangential directions.* A relation between penetrance and structure is indicated by the fact that a group of measure-

* C. H. Teesdale, Project L-129, First Progress Report. Files of the Forest Products Laboratory.

ments of redwood fibers made at the laboratory showed the proportion between length and width to be as 96 is to 1.

In loblolly pine and the majority of the conifers the summer or late wood penetrates before the spring or early wood, in spite of the thick-walled elements of the former. Plate I, figure 5, shows a piece of western larch summer or late wood in cross-section, and Plate I, figure 2, shows both the spring and summer wood in pine. It is the full penetration in the summer wood and slight penetration of the spring wood which gives the alternate black and white stripes so familiar on the quartered face of a split pine paving block which is not fully treated.

The bordered pits which are permeable to water in the living tree do not appear, from the present experimental data, to aid to a great extent in creosote penetration. The regions where they are largest and most numerous—that is, the spring wood—usually absorb less, sometimes no, oil. Moreover, any absorption here takes place only after the elements with smaller pits are already treated.* The degree to which the cell wall transmits creosote is problematic. It is easy to show that the wall absorbs creosote. Nevertheless, thin-walled parenchyma cells, such as pith, medullary ray cells, and tyloses, do not permit the passage of the oil to any such degree, even in the most favorable situations, as do the thick-walled summer-wood cells.

The fact cited by Mr. Tiemann†, that dry wood often shows minute checks or "slits," may aid in the explanation of creosote penetration, although as yet we have no evidence that these "slits" extend through all the thickening layers of the cell wall. Well-developed slits are characteristically shown in the cross-section of western larch, Plate I, figure 5. In conifers, they are most frequent in the same regions where the greatest penetration is found, and considerable weight might be attached to this fact if it were not for an experiment on a block of the above-mentioned larch, where serial sections of the dry wood showed a full development of "slits" in the summer wood in both the sap-wood and the heart-wood. These sometimes traverse the mouth of a pit, appear often between pits, or frequently in spiral series criss-crossing in the last-formed thickening layers of adjacent summer-wood tracheids. In spite of the fact that many of these checks were present, as stated,

* Since writing this, I. W. Bailey's paper in the current Forestry Quarterly has given valuable data on the behavior of bordered pits—especially with water solutions. The writer's recent studies also show certain marked differences in the structure and behavior of pits in the spring and summer wood.

† American Railway Engineering and Maintenance of Way Association Bulletin 107, 1909.

in both the sap and heart wood of the piece of larch, only the sap-wood treated with creosote. Therefore, it seems evident that further observations must be made before it is proved that "slits" are responsible for the selective creosote absorption of the summer wood.

The relation of resin canals to creosote penetration in conifers has been overestimated. That the tracheids are the primary factor to be considered in the penetration of conifers has been definitely proved by the results of the treatments described in Mr. Teesdale's report before mentioned. Evidence on this point was also gained from the microscopical experiments. In a considerable number of instances fusiform rays with horizontal resin canals were visible in cross-section on the tangential surfaces of the blocks during penetration. In no case did they afford a free channel for the passage of creosote. The studies on tyloses have shown that these *horizontal* canals in many cases are not open. When they are open they are usually discolored by creosote in the blocks of creosoted wood examined *after* their treatment. Resin was often visible in these canals during treatment. Nevertheless, the supposed mutually solvent action of creosote and resin had no apparent effect on opening up the canals which were surrounded by fully creosoted tracheids. The ray cells also appeared, in the summer wood, to fill with creosote only after all the tracheids adjacent were full. In a few tests made on spring wood alone the general penetration was extremely slow.

These microscopic experiments also showed that a fractionation of entering creosote appeared to take place. The first creosote to appear and fill the lumena of the tracheids was pale amber color, about the shade of the summer wood in pine. This liquid had a concave meniscus, and in good penetrations was soon replaced by a deeper brown liquid which, in a heavy treatment, became seal brown or black. It is also of note that the oil seen in spring wood was almost always one of the lighter shades, and this may to some extent account for the—to the naked eye—uncolored appearance of the alternate bands of spring wood as seen in some species of woods when treated for use as paving blocks, etc. The tendency for the fractionation of creosote has been further confirmed by the work of Mr. Teesdale and some preliminary work on "Wood Membranes" by Dr. Diemer.

V. THE OUTLOOK

Material for new experiments on the penetration of creosote is now in preparation. More delicate methods will be applied to relatively thin, transparent sections instead of using blocks. Observations will be made on the behavior of a single tracheid or group of tracheids.

Microchemical studies on the composition of sap and heart wood and its relation to penetrability are also planned.

Another field of work to which the study of the occurrence of tyloses in pines has given impetus is the question of resin production from the side of the turpentine industries. Plate IV, figure 2, shows a cross-section of long-leaf pine cut just above the peak of a chipped face. The response of the tree to the wound stimulus of the chipping is very evident in the great increase in the number of resin canals as well as parenchymatous tissue in last years of growth, shown at the top of the figure, as compared with the normal rings at the bottom of the figure. That there is a reduction at this point in the width of the growth rings and in the thickness of the cell walls composing the summer wood is also remarkably clear from this figure. Such marked response, however, does not appear, from the material at hand, to extend more than a few inches above the wound. The possible advantage of removing a still thinner chip than is now customary, and so not extending the face so rapidly up the tree, may yet be used as a means better to conserve the energy of the tree without decreasing the yield of oleo-resin.

This is only a brief outline of the nature of the work and some of the investigations belonging to this phase of the study of forest products. The longer the work continues, the better and clearer becomes the conception of the problems to be solved and of the means for concentrating energy upon their solution. Added knowledge will not only open the way to new practice, but it will also bring about improvements in the methods now used. The reduction of waste and increase in efficiency due to intelligent utilization will help toward the realization of that much-desired object, the proper conservation of resources.

Description of Plate I

Figure 1.—Cross-section of a steel ball highly magnified.

Figure 2.—Cross-section of a piece of wood at same magnification as the steel.

Figure 3.—Bordered pits on the radial walls of the pine tracheids, highly magnified.

Figure 4.—Grating connecting the segments of the tubes or vessels which function as sap-conducting channels in red gum, *Liquidambar styraciflua*.

Figure 5.—Western larch, *Larix occidentalis*, summer or late wood, showing small checks or "slits" in the inner thickening layers.

Figure 6.—Radial surface of a creosoted hickory block showing transparent untreated tyloses, t, in vessel cavity.

DESCRIPTION OF PLATE II

Six Woods Used in Wagon Construction Reproduced at the Same Magnification and Therefore Directly Comparable

The following prominent structural features are indicated as follows:

AR—Annual ring.
E—Spring or early wood.
L—Summer or late wood.
V—Vessels or pores.
T—Tyloses, when present.
MR—Medullary rays.

FIGURE 1.—A typical ring-porous wood, a "commercial" white oak, *Quercus minor*.
FIGURE 2.—Pignut hickory, *Hicoria glabra*.
FIGURE 3.—Oregon ash, *Fraxinus oregona*.
FIGURE 4.—A typical *diffuse porous wood;* tulip, *Liriodendron tulipifera*.
FIGURE 5.—Elm, *Ulmus americana*.
FIGURE 6.—Osage orange, *Toxylon pomiferum*.

DESCRIPTION OF PLATE III

A Non-porous Wood

Short-leaf pine, *Pinus echinata*, showing at the same magnification the three planes in which each collection specimen is cut and the way in which the characteristic features of each plane are illustrated.

FIGURE 1.—Transverse or cross-section.

Shows: AR—Junction of two annual rings.
t—Tracheids or "fibers."
L—Summer or late wood.
RC—Vertical resin canal.
MR—Medullary rays.
E—Early or spring wood.

FIGURE 2.—Radial or "quartered" surface.

Shows: T—Tracheids or "fibers."
B—Bordered pits.
MR—Medullary rays.
RT—Dentate ray tracheids.

FIGURE 3.—Tangential or "bastard" face.

Shows: T—Tracheids.
B—Bordered pits in profile.
MR—Linear medullary ray.
FMR—Fusiform medullary ray.

Description of Plate IV

Figure 1.—The Jung Thoma sliding microtome used for making thin sections of wood for microscopic study.

Shows: A section lying on the knife blade and a typical strip from which study material is obtained resting on the knife case.

Figure 2.—Long-leaf pine, *Pinus palustris*, cross-section just above the peak of a chipped face.

Shows: Relative size and number of resin canals normally (NRC) and after chipping (RC).
Also the quality of the summer wood formed in the two cases—NL and L.

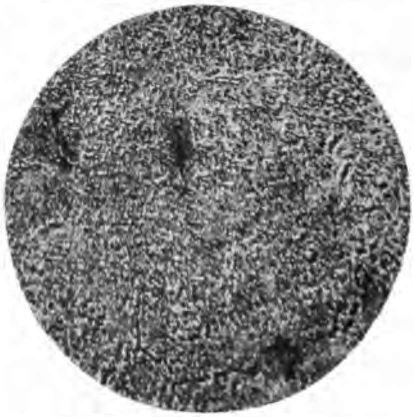
Figure 3.—Fungus mycelium in a radial section of pine.

Figure 4.—Chemical pulp made from aspen, *Populus tremuloides*.

Shows: The "fibers," f.
A vessel segment, v, in the center of the field.

Plate I

1.



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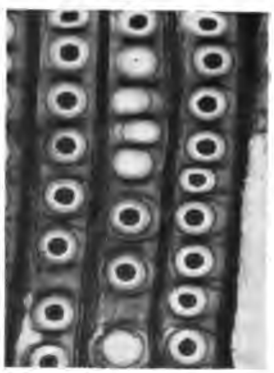

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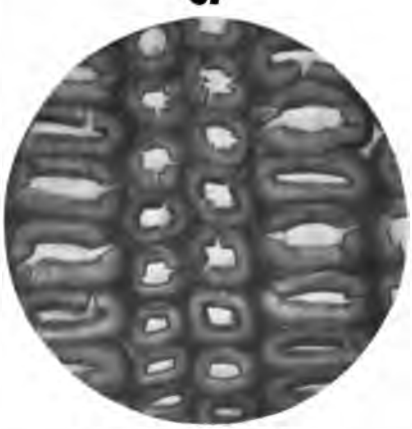

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Plate II

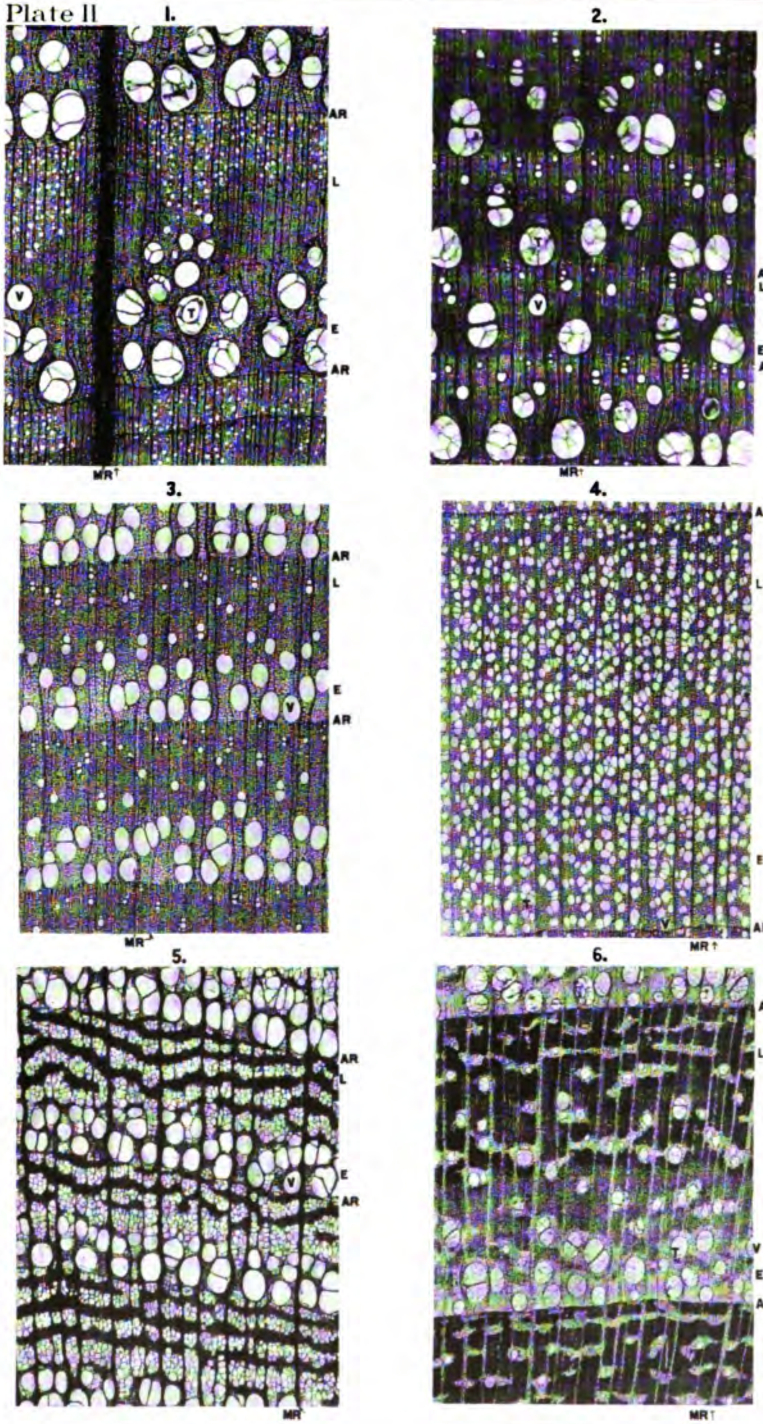

Plate III

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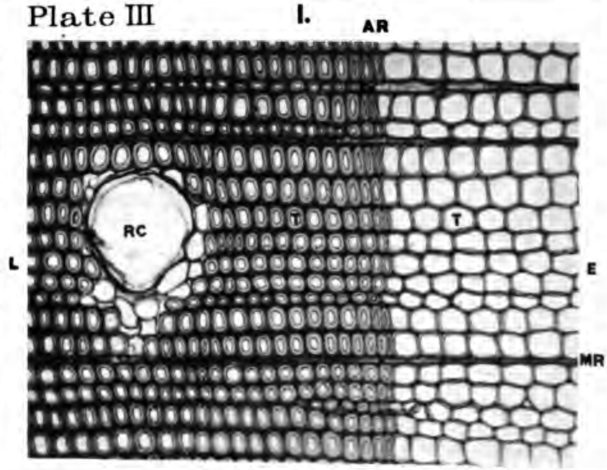

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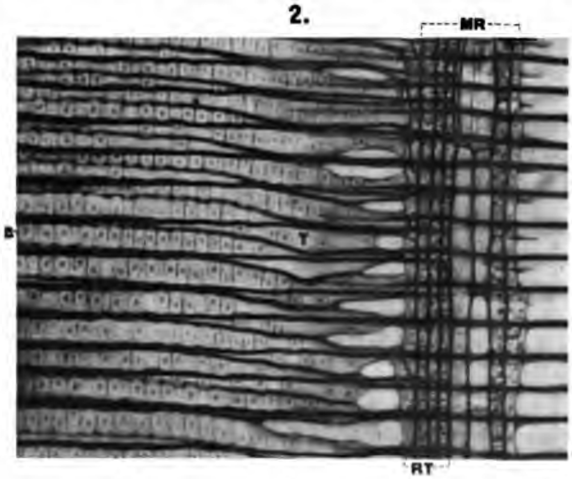

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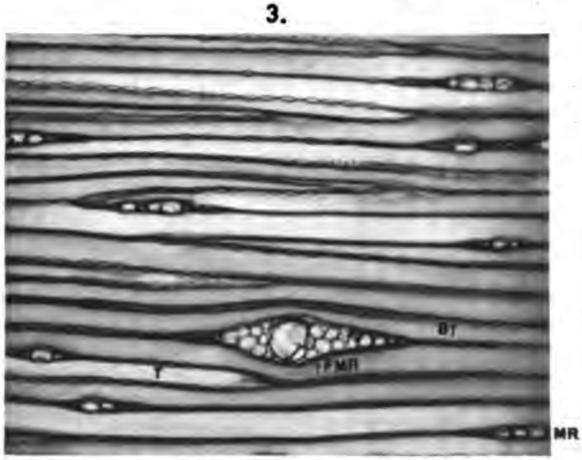
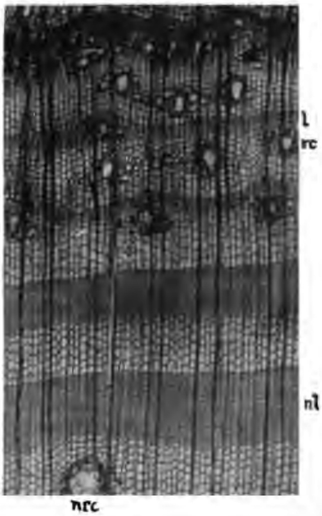


Plate IV

I.

2.



3.

4.

HOW CAN WE MAKE OUR STUMPAGE MORE VALUABLE?

BY HOWARD F. WEISS

Delivered before the Society March 6, 1913

Professor Silliman, writing in the *American Journal of Science,* in 1883, of the Seneca oil spring, says:

"It rises in the midst of a marshy ground, a muddy, dirty pool of about 18 feet in diameter. The water is covered with a thin layer of petroleum, which they collect by skimming like cream from a milk pan. It has a very foul appearance like dirty tar or molasses, but is purified by heating and straining while hot through flannel. It is used by the people of the vicinity for sprains and rheumatism and for sores on their horses. It is not monopolized by any one, and is carried away freely by all who care to collect it, and for this purpose the spring is frequently visited."

Here is what J. J. McLaurin quotes in his "Sketches in Crude Oil" from the experience of earlier settlers:

"We were invited by the chief of the Senecas to attend a religious ceremony of his tribe. We marched upstream half a league, where a large band had arrived some days before us. The great chief recited the conquests and heroisms of his ancestors. The surface of the stream was covered with a thick scum, which, upon applying a torch, burst into a complete conflagration. At the sight of the flames the Indians gave forth a triumphant shout that made the hills and valley re-echo again."

Those of you who are conversant with forest conditions in this country will see in the above quotations two words typifying our forest practice—skimming and conflagration; they are, unfortunately, "American forestry."

It is the "skimming" aspect of forestry that I wish to call to your attention, but before doing so let us analyze a little further the history of the petroleum industry, and see what lessons we can draw from it. In so doing, I wish to state at the outset that I am absolutely opposed to certain pernicious methods used by some petroleum companies to secure the monopolistic position which they now enjoy. So I pass any discussion of them with the confidence that able minds can and will find practical means of successfully grappling with them.

Although the boring for oil began about 1810, it was not until 1859 that the industry established itself. During that year about 2,000 barrels of petroleum were produced. Our production is now about 200,000,000 barrels yearly, and the total value of the products is about $125,000,000. In 1889 there were 94 refineries in the United States; 10 years later there were 67, a decrease of 28.7 per cent. But while this shrinkage occurred in the number of plants, the capital invested increased 23 per cent and the annual output from 35,000,000 to 58,000,000 barrels, or 61 per cent. In the tremendous expansion of this industry there are two commendable things which stand out prominently and bear directly upon an analysis of the lumber situation; they are:

1. The development of new uses through extensive experimenting.
2. The consolidation of scattered interests into working units.

Without these, the industry would still be undeveloped. From such primitive uses as crude fuel and salve hundreds of products have, *through painstaking research*, been derived, each of which is adding its share of profits from this one great natural resource. It is well to keep this fact in mind.

What is true of the refining industry is true of the packing industry, the steel industry, and other big successful enterprises. How different from the slogan circulated this spring by the lumbermen at one of their recent conventions, "Shall we man the guns now or the pumps later?" What are "the guns"? In the author's opinion they are:

1. Improved manufacture and the development of new uses.
2. The consolidation of scattered interests into workable units.

In American forestry destructive and wasteful methods begin in the forests with the cutting of the timber, and continue until the finished product is loaded for shipment. Each step takes its share from the profit bag and cripples the permanency of the industry. To even attempt a discussion of improved methods in forest management would prolong this paper to a volume. I will not attempt it, but will dwell primarily on the efficiency with which our forests are now being utilized and the possibilities of increasing this efficiency. Of what value is it to grow timber if we are going to wantonly destroy it?

Three rather distinct lines for improvement in forest utilization present themselves:

1. The utilization of waste material resulting from manufacture.
2. Improvement in sawing logs.
3. The conversion of timber into that use for which its intrinsic properties best fit it.

The wastes (which, of course, are subject to wide variation) at present occurring in converting a normal tree into lumber are about as follows:

2	per cent in stumps
18	" " " tops
12	" " " dust
10	" " " bark
8	" " " slabs
8	" " " edgings and trimmings
4	" " " shavings
62	per cent—total

In other words, out of the total volume of the living tree only 38 per cent is now utilized, the rest being practically a total loss; some of it, it is true, is used for fuel; but even then the most wasteful means are employed. With an industry having such enormous losses it is only reasonable to expect that it cannot be maintained in a permanent flourishing condition. The petroleum industry, however, faced a problem no easier of solution.

Obviously, our big problem then is to utilize this waste. How can we do it? The best means are not at present thoroughly known; in fact, this phase of the business is still in the egg. However, certain progress has already been made and commercial success in some lines already established, as will be shown further on. For purposes of this discussion we will divide our various trees into three classes, namely:

1. Resinous conifers like long-leaf pine, Cuban pine, etc.
2. Non-resinous conifers like white pine, hemlock, spruce, etc.
3. Hardwoods like beech, maple, hickory, elm, etc.

For resinous woods the following operations are possible:

1. The stump, top, slabs, edgings, and trimmings can be hogged, shredded, and mixed with the dust and shavings for conversion into ethyl alcohol, collecting turpentine and some acetic acid as by-products. After such conversion about 65 to 70 per cent of the material will still be available for fuel.

2. The stump, top, dust, and shavings can be hogged, shredded, and converted into products as in case one, while the slabs, edgings, and trimmings can be made into pulp.

Let us illustrate these principles as follows:

A long-leaf pine tree 12 inches in diameter breast high and 75 feet high will have a volume of about 21 cubic feet. According to present practice the tree will be felled and sawed into lumber, 100 feet b. m. being taken from it, which, valued at $15 per 1,000, will make the gross

value of its products $1.50. If, now, the rest of the tree were utilized as in case one, there could be recovered one-fifth gallon of turpentine, worth 8 cents, and 3 gallons of ethyl alcohol, worth $1.35, making the gross value of the tree $2.93, or an increase of 95 per cent. The increase in the net profits would be about 140 per cent.

If operation number two were followed there would result 0.12 gallon turpentine, worth 5 cents, 2 gallons ethyl alcohol, worth 90 cents, and 60 pounds of paper, worth $1.80, a total gross value for the tree of $4.25, or an increase of 183 per cent. The net increase in profits would be about 240 per cent.

Nor is this all. The tree could be orcharded three years prior to cutting without depreciating the value of the lumber. This would yield three-fifths gallon of turpentine, worth 24 cents, and 18 pounds of resin, worth 45 cents, or a total of 69 cents, and net profit of 15 cents.

If we do away with the sawmill entirely, and substitute a paper mill, converting the whole usable length of the tree into paper, we could produce about 245 pounds of pulp, worth as wrapping paper about $7.35, which, added to the 69 cents from turpentine orcharding, would make the gross value of the tree about $8.04, and the net profit $2.60. This calculation does not include any turpentine which could be collected during digestion, and it figures the cost of wood at about $10 a cord, whereas, with pine stumpage at $2.50 per thousand, its actual cost per cord would be about $1.50. Surely, then, these figures are conservative. The possible effect of these various operations on the gross value of products obtainable from long-leaf pine is shown graphically in figure 1.

Except for the collection of turpentine and resin, all the operations suggested above are possible for non-resinous conifers like hemlock, spruce, tamarack, etc. The value of spruce for paper has been so long understood that it finds one of its chief uses now for that purpose. I do not contend that all non-resinous conifers can be converted profitably into paper; but many of them—in fact, most of them—can be used either alone or in mixture with other species, and if so used the value of the products taken from them will be increased.

The more efficient utilization of hardwoods presents an entirely different problem from softwoods. Hardwoods, as a rule, are seldom adapted to paper-making, and, of course, contain no turpentine or resin. Hardwood waste can, however, be profitably utilized for the manufacture of ethyl alcohol, although practically nothing has been done so far along this line. If destructively distilled, such waste will yield products in paying quantities.

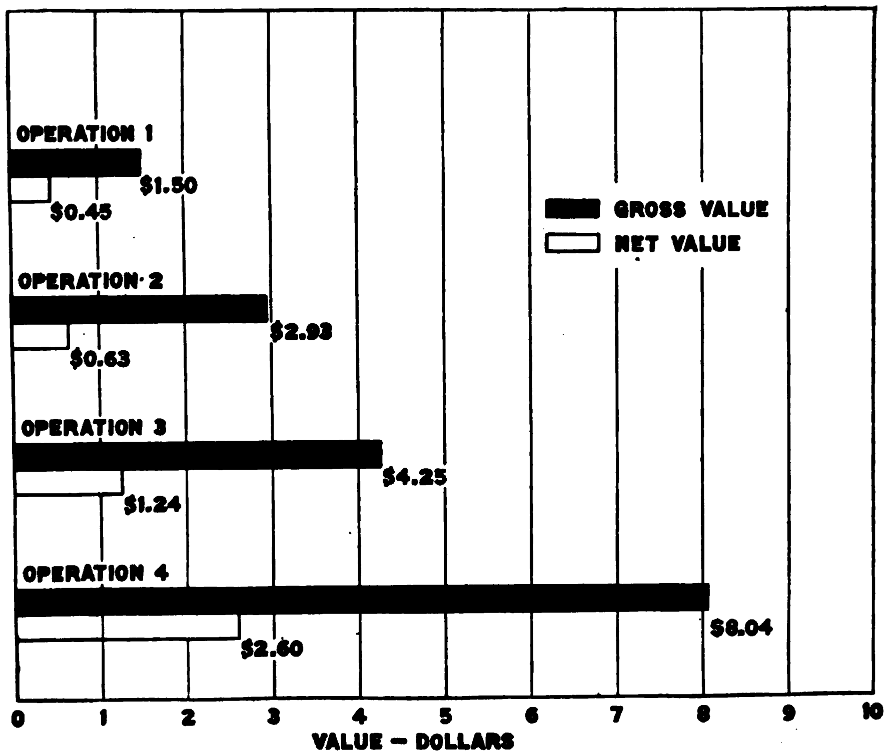


FIGURE 1

The operations possible for the utilization of hardwood waste may be illustrated as follows:

Assume a yellow birch tree 16 inches in diameter breast high contains 35 cubic feet:

Operation 1. Suppose the usable top, limbs, slabs, edgings, and trimmings, comprising about 22 per cent of the tree volume, are destructively distilled. They will yield 14 pounds of acetate of lime, worth 35 cents, 0.7 gallon of methyl alcohol, worth 20 cents, and 3.6 bushels of charcoal, worth 22 cents. According to usual practice, the tree would simply be cut into lumber yielding about 168 feet, board measure, worth about $3 ($18 per 1,000). By the addition of the operations suggested this would be raised to $3.77, or a gross increase of 26 per cent.

Operation 2. If, in addition to the above, the dust and shavings were converted into ethyl alcohol, they would yield about 1.5 gallons, worth 67 cents. The gross value of the by-products would then be $1.44, rais-

ing the total gross value of the tree to $4.44, or an increase of 48 per cent. In addition to the ethyl alcohol, appreciable quantities of acetic acid could be collected, but, to be conservative, this was not figured in the example.

Next in importance to the utilization of waste comes the correct sawing of logs. A lumberman would not attempt to saw limbs off his trees and manufacture them into boards. Of course not; it would be ridiculous; but he will attempt to saw logs that bring him nothing but a loss. What is the essential difference? If we call a limb a log, would he saw it? It stands to reason, with a raw material varying as much as a tree varies in shape, size, character, etc., there must be certain parts of it that pay best, and other parts that pay nothing at all; in other words, the profits cease after a certain point has been reached, and *closer sawing means a loss.* How many lumbermen take advantage of this fact and know where that point is in their operations?

About eight years ago several hundred trees were cut in the Adirondacks and sawed into lumber. The size of each tree was measured, as was also the size and number of each log cut from them; then the logs were run through a sawmill according to the usual practice, and the grade and amount of lumber cut from each determined. About that time $11 per 1,000 feet b. m., f. o. b. mill was a fair cost for stumpage, logging, and manufacture under these conditions. A result of this study is shown graphically in figure 2. Every yellow-birch tree less than 17 inches in diameter was manufactured at a loss. What was true for yellow birch was also true for sugar maple and beech, *and this condition is true in most sawmills now operating in the United States.* If yellow-pine operators sawed only clear, straight logs 10 inches and over in diameter, they could increase the average value of their mill run about $5 per 1,000 feet, b. m.

What, then, should be done with these small logs? Waste them? Certainly not. Two courses are open: If they come from small trees, let these trees grow; if they come from top logs, manufacture them into products that will yield a profit. It may be only a hewn tie, or it may be pulp or alcohol, but whatever it is, let it be something that will *yield a profit* and not *eat into the profits.*

It is entirely possible to saw logs with least waste, but at the same time operate inefficiently. By this I mean that the timber is not put to the best use to which its intrinsic properties fit it. Woods, as you know, differ greatly in their physical and mechanical properties. If these are not considered in manufacturing, the logs are, to my mind, just as badly handled as those that are sawed improperly. For example,

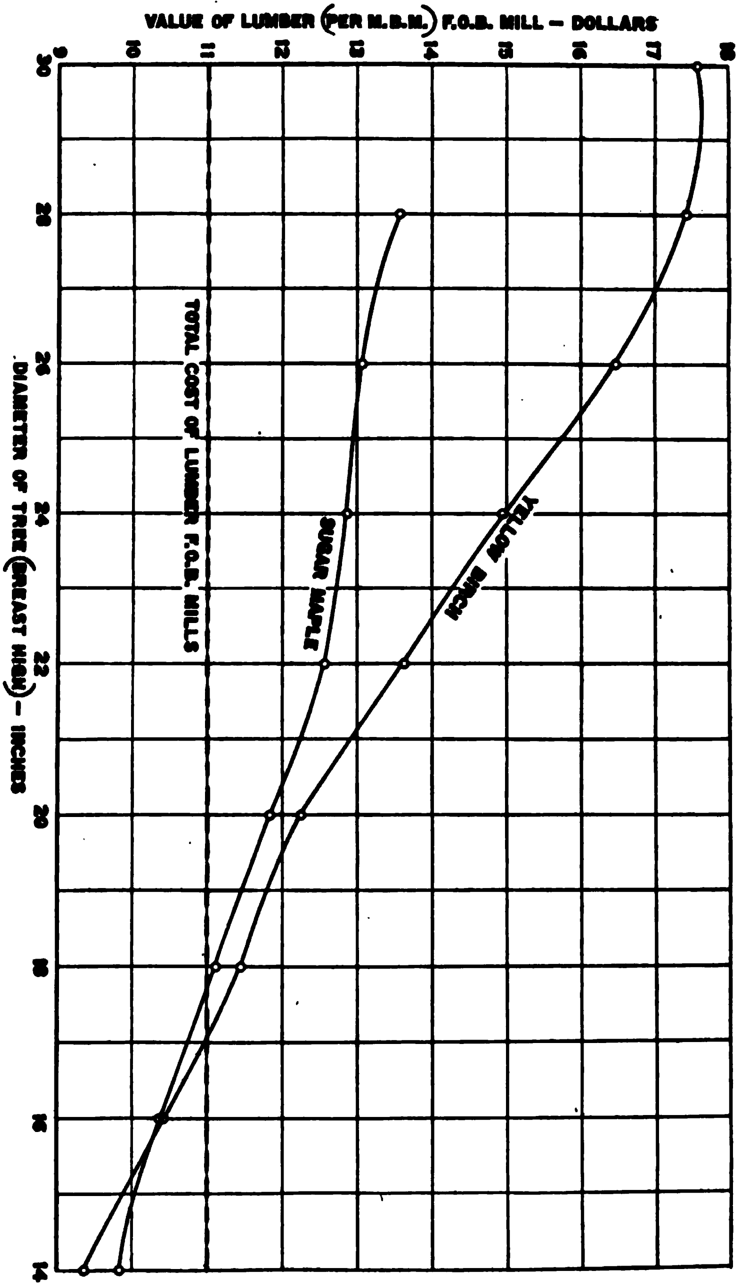

VALUE OF LUMBER (PER M.B.M.) F.O.B. MILL — DOLLARS
9
10
11
12
13
14
15
16
17
18
TOTAL COST OF LUMBER F.O.B. MILLS
SUGAR MAPLE
YELLOW BIRCH
DIAMETER OF TREE (BREAST HIGH) — INCHES
14
16
18
20
22
24
26
28
30

FIGURE 2

I have seen many ties made of white oak, hickory, cherry, butternut, and even walnut, and the specifications of many of our leading railroads still call for such ties. To my mind such practice is an economic waste. I saw last winter a large yellow-pine sawmill priding itself on the utilization of its low-grade stuff, which it was converting into boxes. Yellow pine is one of the poorest materials for boxes. Its make-up is against such use. Not until the lumberman pays more attention to the intrinsic value of his timber will these conditions get better. He is killing the goose that laid the famous egg.

But daylight is breaking! The Du Pont Powder Company has now in operation a plant for manufacturing ethyl alcohol from mill waste. It surely is gratifying to see the conveyor which formerly dumped its burden into a massive burner, filling the surrounding air with smoke and cinders, now dumping it into a hopper from which the material is gradually converted into refined alcohol at the rate of 1,000 gallons a day. The Fullerton Lumber Company is following suit, and is now erecting a plant at a cost of $750,000 that will have a capacity of 5,000 gallons of alcohol daily. Thousands of long-leaf-pine trees are felled annually without having been tapped, although a net profit of from $500 to $1,000 per crop can be realized without in any way damaging the timber. The Houston Oil Company knows this and is profiting by it. Englishmen have discovered the value of our long-leaf pine for paper-making, and are now erecting a million-dollar plant in Mississippi for this purpose. Some progressive lumbermen in East Texas were not satisfied with wasting their slabs, and got together and erected a paper plant to utilize them. They are now underselling their competitors in the Minneapolis paper market. The Goodman Lumber Company realized it was losing money by trying to convert its small hardwood logs and tops into lumber, and is now erecting a destructive distillation plant to bring this material to the mill where it will be manufactured at a profit and not at a loss. Other operators at Cadillac have also been doing this successfully.

But such cases are all too few. A large percentage of the profits that have been made in the lumber business has come through the rise in stumpage value, and *not through the manufacturing end of the business.* Furthermore, this rise has been brought about largely through curtailment in the supply of our raw material, which, from the standpoint of the nation's welfare, is the worst way to cause a rise. If, now, stumpage values do not rise appreciably in the future, obviously those concerns which acquired their holdings at comparatively high prices will be the first to feel seriously any slump in the market; in fact,

this condition has already prevailed. It is largely the result of great economic changes that are in progress, which neither the lumbermen nor any one else can stop. To expend energy in combating them through advertising or any other way would be as bootless as old Canute's attempt to command the sea. Unquestionably, the only logical course for the lumber interests to pursue is to mold present practice to meet modern changes; to find, as in the examples I have cited, some other way to work. If history and experience are worth anything, they at least teach us this.

What are these economic changes? Tersely, they may be summarized in two words—better construction. About 50 per cent of all lumber is consumed by the building trades, where it comes in direct competition with clay products, cement, and steel. With the development of the country and the construction of more permanent buildings the role of lumber in such construction is bound to play a diminishing part. Already the differential in cost between buildings of wood and those constructed of other materials is, in many localities, inappreciable. Furthermore, the tendency is for many of the so-called substitutes to decrease rather than increase in cost. Take cement, for example: Its cost has gradually dropped from \$2.15 per barrel in 1883 to \$0.81 per barrel in 1909. How can lumber permanently rise in value in the face of such competition? Obviously, new uses must be found; new channels for exploitation must be developed. What is true of buildings is also true of other forms of industrial development. Note the almost complete annihilation of the wooden coal car; the rapid introduction of the steel passenger car; the increasing use of steel and concrete poles and posts; the gradual elimination of wood in vehicles; the concrete silo; and kindred other commodities where wood once held complete sway. Of course, the counter-argument is that although the use of substitutes is increasing, so is the country, and the demand for wood will remain strong enough for it to maintain at least its present status. Were I a lumberman I should prefer not to be blinded by such dodo optimism. The demand for high-grade lumber will probably always be with us, as is indicated by the character of our lumber exports; so the by-products plant, which is primarily adapted for waste and low-grade material, will not annihilate the sawmill, but simply supplement it.

We have considered the losses due to waste, to improper sawing of the logs, and to misapplication of the timber, and have indicated how the correction of these evils would increase the value of the products derived from the timber. If these practices were followed it would mean an increase in the value of the stumpage, since is not stumpage

value dependent upon the value of its products? I wish to repeat again that the suggestions for increased utilization which have been made are but suggestions. The gap between suggestion and practical accomplishment is a wide one, and a tremendous amount of work must be done before this gap can be spanned. This leads us to our second big problem, viz., suitable working units.

To make practicable the above technical suggestions there must be a sufficient amount of material with which to work, and this material *must be available for the future, as well as the present.* It is entirely feasible for a company to erect a sawmill and wipe out a fine forest in ten years, after which the plant can be abandoned with a profit. Not so with most of the by-product industries which have been mentioned. They are too costly for mushroom operation. It is largely because of this that greater numbers of forest-products plants are not in operation. If the number of such plants is to increase, we must have for them an assured supply of raw material for years to come. In one way this is a commendable feature, because it adds permanency to the management of forest areas and will make companies interested in growing timber on these areas—a phase in which few of them are now concerned. We all admit that enormous wastes are taking place, but these wastes can never be utilized until the thousands of scattered holdings are combined into efficient working units and hundreds of inefficient sawmills now operating and furnishing lumber to the open market are exterminated. Of the 42,000 sawmills in this country, over 28,000, or 6 per cent, have a capacity of between 50,000 and 500,000 feet, b. m., per year. But the waste caused by them is in the aggregate not nearly so great as the waste caused by their larger brothers.

Last spring I had occasion to study the hardwood situation along the Tennessee River. The following inventory of what I saw at one of the mills is illustrative of that region:

> Timber: The finest hardwoods, of hickory, ash, walnut, chestnut, etc.
>
> Equipment: One portable engine and a 54-inch circular saw, 4 mules, 1 horse, 6 chains, 2 bales of wire, and 3 live dogs.
>
> Capacity: 5,000 feet, b. m., per working day.
>
> Operative force: Head boss and sawyer, "the old man;" carriageman, "the old man's" oldest son; fireman, "the old man's" second son; logging bosses, swampers, and teamsters, "the old man's" two younger sons; cook, "the old man's" woman; cookie, "the old man's" oldest daughter; emergency help, "the old man's" six other children, general assistants too young yet to work.

Selling price of product: Slab of bacon, sack of potatoes, sack of flour, plug of tobacco, horse feed, felt hat, a gingham dress, and other incidentals; in short, the "old man's" and his family's existence.

Against such a combination the "modern" sawmill has to compete. No wonder many of them found it cheaper to shut down completely and buy their lumber from such mills during the recent panic. I do not advocate and *am by no means in favor of depriving these little backwoods sawyers of a living.* They have as much right to live as any of us; but what I do believe is that in general their operations should cease with the conversion of the standing tree into logs and delivery at a marketable point. There is no more reason why such little operators should send lumber to the general market than there is for farmers to send dead pigs to Chicago. On the other hand, there is just as good a reason why these little fellows should make lumber for their home consumption as there is for the farmer to kill his pigs for home consumption. I realize the monopolistic danger of the scheme advocated, but monopoly can and will be overcome. There is a sharp distinction between efficient operation and monopoly. If our forests are to be efficiently used and not ruthlessly destroyed, we must have them combined into sufficiently large working units, so that conservative utilization is practical. To do this the actual purchase and ownership of the land by large holding companies may not always be necessary. But the increased efficiency of utilization would make it impracticable for the destructive and inefficient mills, whether large or small, to operate, because they could not compete with the efficient mills, and would consequently be undersold. Not until this is accomplished can forest utilization ever approach the efficiency with which other big resources are now used.

It has been argued that such close utilization would result in forest annihilation rather than conservation. If giving stumpage an increased value means forest destruction, then this charge is true. To my mind, increased stumpage values on *forest areas* make practical the more intensive management of those areas, and that is just the result desired. Who is going to employ a forester to administer a forest area the returns from which do not even pay the forester's salary? If, now, you can through more efficient utilization increase the revenue from that forest area so that its administration pays, then you have commercially justified such administration, and not until then.

To sum up: It is the author's opinion that American forestry urgently needs:

1. Better utilization of its forests.
2. Consolidation of scattered holdings into workable units.

For most effective results these two requirements cannot be separated.

Providing the working unit is of sufficient size, better utilization can be brought about in common practice by:

1. Converting a large percentage of forest and mill waste into merchantable products, such as alcohol, paper, turpentine, acetate of lime, etc.
2. Cost-keeping the value of the products cut from logs of various kinds and sizes, so as to know definitely the minimum limits of profit, and thus converting what are now losses into profits.
3. Considering the physical and mechanical properties of each kind of wood and then putting the wood to that use for which these properties best fit it, thus getting larger returns from the raw material.

Adherence to the above will unquestionably raise the value of stumpage, because more will be got out of stumpage. It will make practicable more intensive forest management than is now possible, and will place the practice of forestry on a broader, more profitable, and more permanent basis than it is at present.

THE FUTURE UTILIZATION OF TIMBER

BY R. S. KELLOGG

Delivered before the Society March 6, 1913

At the outset I wish to confess that six or seven years ago I would have undertaken the discussion of this subject with a great deal more confidence than I do now. There are a multitude of phases of America's third greatest manufacturing industry, and perhaps too intimate acquaintance with some of the details prevents one from getting a proper perspective. It is, therefore, with much hesitancy that anything is written upon the topic presented here tonight, and I have little hope that anything I may say will be in any way of original or particularly useful character. The best I can do is to point out some reasons why timber utilization is at present so incomplete, and, by contrast, indicate conditions which make fuller utilization practicable.

I would like to suggest that the topic upon the printed program for the season—"Future Utilization and Marketing of Forest Products"—is unfortunately worded. By calling the theme for discussion "The Future Utilization of Timber," we shall better get at the underlying idea. In the first place, there can be no *utilization* without a *market;* secondly, timber *is utilized* when it reaches the stage of a forest product, if my understanding of the term product is correct.

The wholesale timber waste—I believe we put it at from 50 to 75 per cent in the report of the Conservation Commission—is caused very much more by lack of a market than by lack of desire to utilize on the part of either producer or consumer. Often the entire capital of the lumberman, together with all the funds that he can borrow, is invested in timber. It is not likely that, under such circumstances, he will ruthlessly destroy his property. On the contrary, he makes every effort he knows to utilize his timber closely and to get a profit from his stumpage. The lumberman is very human, like the rest of us. He may be ill-advised sometimes, and poorly informed at other times, but he is generally attending to business and making a fight to decrease waste. We must give him credit for good intentions of this sort, however much there may be to criticise in the results he obtains.

There are only two ways for the owner to make money out of his timber, and, like the rest of us, he would not have bought timber in the first place had he not expected to make money out of it. The first

method is to hold his timber for a rise in stumpage prices, and sell it when he is satisfied with the increment. This is judicious investment; the same as one buys favorably located farm land, city lots, or other property that in all human probability will rise in value. The second method which the timber owner has of making money is to log and saw and market the products, the net balance at the end of the operation being the price he realizes for his stumpage. This necessitates that the timber owner become proficient in the manufacturing and merchandising of a great commodity.

Lumbermen buy large tracts of timber to insure sufficient supply of raw material to warrant the erection of costly manufacturing establishments, and it is as owners of stumpage and beneficiaries of rising stumpage prices, rather than as manufacturers and sellers of lumber, that timber owners have made money. Only during periods of quick rises in lumber values do lumbermen make any considerable profit purely out of their manufacturing operations. A permanent rise in lumber values quickly goes back to stumpage, and stumpage rises hold, as the most cursory examination of the curves for stumpage and lumber prices during the past 40 years will quickly convince the observer. This is because lumber manufacturing is a highly competitive industry. With anywhere from 40,000 to 50,000 mills, big and little, sawing away from the Atlantic to the Pacific and from Mexico to Canada, with as yet a relatively large supply of raw material, the physical and commercial conditions are lacking which are necessary for the formation of the organizations popularly known as "trusts." When, therefore, lumber prices rise, the sawmill owners quickly bid up stumpage prices in order to get logs. When lumber prices fall off, as they have many times, stumpage owners hold their prices at the previous level, in the belief that a succeeding rise in lumber prices will again benefit the timber owner, and so far the timber owner has never been disappointed. This condition has been clearly illustrated during the past six years. In 1906, and early in 1907, lumber prices reached the highest point known to date. During the four years following the panic of October, 1907, the prices of our most important kinds of lumber averaged from $3 to $6 below the previous level. During all this period, however, stumpage prices either remained stationary or, in some instances, actually increased. With the higher *lumber* values that now prevail, we may expect *stumpage* values to move up another notch. Some ten years ago, perhaps, one of our most distinguished lumbermen made the flat-footed assertion—"the price of stumpage never goes down." I have never heard this statement questioned by any competent observer. One of our most

distinguished foresters says that "forestry is possible only with constantly rising stumpage values," because the natural growth of timber does not exceed 2 per cent annually, which is insufficient to attract capital. He was speaking, of course, of private forestry. If the Nation, or States, deem it good public policy to practice forestry for a net return of less than 2 per cent, or nothing at all, that is an entirely different matter.

We can forecast something of future timber utilization through an examination of conditions which in the past have prevented good utilization. For this reason, I shall quote from book records of two lumber manufacturers for whom I can personally vouch. The first operates in Central Wisconsin, and the second in the Upper Peninsula of Michigan.

The first firm marketed a stock of eight million feet of hemlock lumber from November 1, 1910, to October 31, 1911. Deducting freight, commissions, discounts, allowances, cost of millwork and loading, the receipts for the lumber in the pile rough at the mill were exactly $10 per thousand. This was for a stock which ran 56 per cent No. 1, 20 per cent No. 2, and 24 per cent No. 3; slightly better than the average. Taxes, insurance, interest, and selling expense amounted to $1 per thousand, making a net price of $9 per thousand. Sawing cost $2.75 per thousand, leaving $6.25 for the lumber in the log. Logging and carrying to the mill cost $7 per thousand, log scale, at the lowest calculation. Allowing 30 per cent overrun, this amounted to $5.40 per thousand feet of lumber, or but little more than actual operating cost, with no allowance for stumpage, taxes, and interest on standing timber. Were the mill so situated that all the lath, tanbark, and mill waste could have been marketed at a fair price, the net return from these products would not have amounted to more than $1.75 per thousand feet of lumber.

The second firm, which did a large business in 1911, received $6.44 per thousand for its No. 3 hemlock. The manufacturing cost—*i. e.*, sawing, piling, shipping, and selling—was $3.69 per thousand, and administration cost—*i. e.*, office expense, salaries, depreciation, interest, and taxes—$2.84 per thousand, a total of $6.53. Logging cost $4.50, and delivery to the mill $1.20, or $5.70 per thousand feet of lumber, making the total cost $11.73 for lumber which sold for $6.44, with no allowance for stumpage, which perhaps should not be charged against the cull product. On its entire hemlock sales of ten million feet this firm received a net price of $9.73 per thousand, against a production cost of $10.82, with stumpage charged at $3 to $3.50, according to location—a loss of $1.09 per thousand on this basis.

This firm also received a net price of $8.65 for its No. 3 ash, $8.42 for No. 3 elm, $6.55 for No. 3 hard maple, $7.75 for No. 3 soft maple, and $7.86 for No. 3 birch—all produced at a cost of not less than $12 per thousand.

These are typical examples of conditions that prevailed for four years. For hemlock they meant that, in the most favorable situations, the manufacturers got from $1 to $2 per thousand for stumpage that could not be purchased for less than $2 to $3, and that in other situations there was no return for stumpage. For low-grade hardwoods they meant that the production was at an actual loss of several dollars per thousand.

It was such market conditions as those just mentioned that led one of the most capable and experienced Wisconsin lumber manufacturers—a man grown gray in the battle, and who has since passed away without leaving the fortune lumbermen are popularly supposed to possess—to give his woods foreman the following directions for cutting birch logs, one of the finest hardwoods that ever grew:

> "Cut at least ¾ of all logs 16 ft. long. Long-butt every tree which shows root or stump defect extending 4 inches in diameter at the heart. Cut no 10-ft. logs unless 12 inches or more in diameter and absolutely free from defects. Cut no knotty logs unless one side of the log is clear.
>
> "Cut no logs whatever that show dote exceeding 10 per cent of the scale of the log. Cut no logs with large rotten knots, bad seams, or *bad* crooks. Cut 16-ft. logs, if perfectly straight and free from all defects, down to 9 inches at the top; cut 14-ft. logs down to 10 inches at the top, if perfect. Cut 12-ft. logs down to 11 inches at the top, if perfect; cut 10-ft. logs—when unavoidable only—down to 12 inches at the top. Leave in the woods 16-ft. logs which are less than 9 inches at the top, 14-ft. logs which are less than 10 inches, 12-ft. logs which are less than 11 inches, and 10-ft. logs which are less than 12 inches.
>
> "Do not skid any logs which are less than 18 inches in diameeter which show more than 10 per cent of defect of any kind. Cut lengths in medium size timber not more than 2 inches over the indicated length, and in large timber not more than 3 inches over—to save trimming on thick plank. All logs 12 inches or less at the top end must be free from defects."

This lumberman issued practically the same cutting instructions for rock and soft elm as for birch, permitted ash logs to be taken if they contained 40 per cent clear lumber, allowed basswood logs down to 7-inch tops if perfect, and gave hemlock cutting directions as follows:

"*Long-butt every tree*—cut to 9 inches at top.
"Cut all sound, smooth, straight logs from 22 to 32 ft. long, about 12 inches to 16 inches at top.
"Cut sound, straight logs 18 to 20 ft. down to 10″ to 12″ at top.
"Cut sound timber which is 14″ to 20″ at top 12 ft., 14 ft., and 16 ft. for 2 x 12 joist.
"Cut small sound logs 10 ft. for 2 x 4.
"Cut sound crooked logs 16 ft. for ties.
"Cut all defective logs 16 ft."

For cedar he specified:

"Cut everything which is sound or nearly so, as long as possible for poles.
"Cut small cedar 14 ft. for posts.
"Cut defective stock, any length, for shingles."

The whole purpose of these cutting specifications was, of course, to reduce to the lowest amount the quantity of No. 3 lumber for which the market price was below the cost of production. This lumberman proposed to bring no logs to his mill of which he was in any way doubtful of his ability to make stand the cost of operation. This, however, still left him with a great deal of low-grade lumber which inevitably developed in the manufacture of his stock, for, unfortunately, trees seldom grow perfectly sound, straight, and without knots and other defects. Were Providence good enough to provide trees of this character with the cross-section rectangular instead of circular, there would be no forest waste left for us to discuss, for it would take all the sawdust to make the steam to run the mill.

I happen to be familiar with two strictly modern sawmills of some 100,000 feet 10-hour capacity. They are about 100 miles apart. The first is in a city where the demand for fuel is good. This mill made a profit of $28,000 on its slabs, edgings, and trimmings last year. The second mill is in the woods, with only the families of the employees to supply with fuel. The wood account of this mill showed a loss last year. Now the owners of the mill in the woods have joined forces with a chemical company and an iron furnace, erected a hardwood distillation plant, and made contracts for the products which indicate a profit sufficient to pay 5 per cent upon the sawmill investment.

Some little light upon the question of timber utilization may be obtained from a study of the following table, which shows approximately the percentage of different grades obtained from the ordinary run of

logs of the four most typical northern hardwoods—birch, basswood, elm, and maple:

	1st & 2ds	No. 1	No. 2	No. 3
Basswood	25	25	23	27
Birch	23	25	23	29
Elm	19	24	24	33
Maple	16	25	25	34

It is generally the No. 3 lumber that is the lumberman's greatest source of trouble in marketing his product. This low end of the product averages close to one-third of the entire lumber output the country over. The bulk of it is used by the box-maker and has but little market except as wanted by the box-maker. The box-making business is one of notorious ups and downs, with little standardization and almost no stability. For the past few months the supply of low-grade northern woods has been very short, and the box-makers have been bidding strongly for No. 3 hemlock and hardwoods, so that at this writing these grades are bringing on the average nearly $5 per M more than indicated by the averages quoted for two years ago. This, however, is a temporary condition, and no lumber manufacturer who is enjoying these remunerative prices for his low-grade product believes that this high level will be permanently maintained. He knows that a normal supply of low-grade lumber will again appear and that the price will fall off sharply, although perhaps not back to the former level. It was the high prices of low-grade lumber in 1906 and 1907 that gave a tremendous impetus to the fiber-box industry, of which the wooden-box man has complained so bitterly, and the present rise in lumber prices is very encouraging to the maker of substitutes for wooden boxes. By the time this paper is read there will be in operation a new water-power pulp mill in Wisconsin, said to have cost two million dollars, whose sole output will be fiber board for boxes. The product of this plant will be made from small-sized jackpine, tamarack, and other woods, and the process used will be based to a considerable extent upon the experiments made in the Forest Service Pulpwood Laboratory at Wausau. While plants like these will increase the market for small-sized timber, they will, on the other hand, decrease the market for low-grade lumber. Again, the present temporary high price of low-grade lumber has caused many box manufacturers to put a sawing equipment in their plants and buy bolts 4 to 8 feet long, of small diameter, which they saw into waney-edged box-boards. Such operations as these will be appreciable factors in reducing the price of low-grade lumber.

It is needless to say that a reduction in the price of low-grade lumber immediately results in an increase of forest waste. This suggests very

naturally that our real problem is that of timber utilization, and that the manufacture of lumber is only one method of utilizing timber. Perhaps it may be necessary in the not far distant future to utilize much timber by other processes than those now common.

The price of forest products, like that of all other commodities, is determined by supply and demand. The Secretary of Agriculture, James Wilson, stated in the Year Book for 1910:

> "The farmer has benefited more than others from the changed conditions which have manifested themselves in increased cost of living. For instance, the product of one acre of corn in 1899 was worth, on the farm, \$8.51, but ten years later it was worth \$15.20, an increase in farm value amounting to 78.6 per cent. Similarly, wheat increased in farm value 114 per cent, tobacco 56.2 per cent, and cotton 65.6 per cent. Ten leading crops taken together—including, besides those mentioned, oats, barley, rye, buckwheat, potatoes, and hay—increased 72.7 per cent in farm value."

I believe that somewhere in the same book the honorable Secretary takes some credit to his Department for this increase in the value of farm crops, in which event he is liable to a charge of inhumanity in forcing some millions of us consumers to pay more than we should for our bread, meat, and potatoes. However, the real truth of the matter is that the production of farm crops in the United States has practically stood still while population has increased, and buying capacity increased still more than population. The cost of living, therefore, has gone up. The farmer has an excellent market for his products; he can ride in an automobile and cuss the "lumber trust."

During the period referred to by the Secretary the increase in lumber production kept fair pace with the increase in population and the general rise in the price level. Therefore, while during the decade preceding 1910 the price of ten leading farm crops increased nearly 73 per cent, the average f. o. b. mill value per M feet of the lumber production of the country increased only 37 per cent. It is probable that the maximum lumber cut of the United States was reached in 1910 with an output of more than 45 billion feet. The high point of white-pine production was turned twenty years ago. The top notch for hemlock was passed six or seven years ago. We are too close yet to get a proper perspective, but it seems certain that the greatest output of yellow pine occurred in 1910, and that the largest hardwood cut was about the same time. The tremendous lumber-producing capacity of the Pacific coast, which awaits only the stimulus of a little better price

or lower freight rates via the Panama Canal to turn out billions of feet of fir and pine, will be offset henceforth by decreases in the cut of yellow pine, hemlock, and hardwoods in the East. It looks, therefore, as if our annual lumber output for some years to come would run from 40 to 45 billion feet. The increase in the use of substitutes for wood, of which lumber prices are only one contributing cause, together with the natural limitation of the lumber output, will bring about a decrease in per capita lumber consumption. Present uses for wood and many uses which will be developed will, however, cause an increase in the total demand, which will be reflected in higher price levels for lumber. The increase will probably be least in the lowest grades and in structural timbers, for here substitutes compete most strongly, while the increase in prices will be greatest in the upper grades of woods which supply fine finishing material and other products for which no really satisfactory substitute is likely to come into general use. Moreover, the lumber production of the future will contain a larger percentage of low grades than at present, due to the increased cutting of smaller and more inferior timber, unless other methods of utilization for timber of this character are developed.

The future, therefore, offers hope in the way of higher average prices for lumber, which mean closer timber utilization. The lumbermen of the older generation labor under some disadvantages compared with modern manufacturers and merchants. They are primarily woodsmen and loggers—men of little book knowledge or technical education, trained in the school of hard experience to combat nature's sternest moods, but unskilled in scientific methods of production and merchandising. This, perhaps, is best illustrated by the only very recent admission by most lumbermen that advertising can play a real part in the marketing of their products. One can pick up almost any magazine and find it full of attractive and interest-compelling advertisements for dozens of substitutes for wood, but until very recently only the reader of the lumber journals really knew that lumbermen existed, and the circulation of all the lumber trade journals in the United States would not add up to one-tenth of the circulation of any one of several of our leading magazines, not counting the women's magazines. The typical advertisement in the lumber journal states that the "Dryasdust Lumber Company Manufactures Yellow Pine" or that "No one else can possibly produce as good hardwood lumber as John Smith." Trade-bringing publicity catches attention, arouses interest in the article to be sold, carries conviction as to its merits, and creates desire for its pos-

session. Few lumbermen have ever been accused of paying for advertisements of this sort.

A distinct mark of progress in the marketing of lumber was set when the manufacturers of red gum undertook to tell the public that their product has some real merits. Now, I should hesitate to say how much of the so-called Circassian-walnut finish that adorns some of our finest hotels and office buildings is nothing but the heretofore despised gum. The manufacturers of yellow pine have insisted upon the merits of their wood for paving blocks until the municipal authorities have the impression that there is nothing else as good. The cypress people have talked cypress in rather extravagant terms, and quoted Government reports profusely for several years, with apparently much satisfaction and profit to themselves. At any rate, they have spent money much more freely than any other group of lumber producers to tell the rest of the world that they are in existence. Not long ago the northern pine manufacturers decided it was time to inform the public that there is still "White Pine: And Plenty of It," and they spent $25,000 in so doing. More recently the red-cedar-shingle manufacturers of the Pacific coast, the short-leaf-pine manufacturers of Arkansas, and the birch and hemlock manufacturers of Wisconsin and Michigan have joined the ranks of general lumber advertisers. All this indicates a distinct step in the evolution of the lumberman. The many substitutes for wood were advertised because their manufacturers had to develop a market. Heretofore the lumbermen have held to the belief that they would continue to get trade in the future, as in the past, because the public must have their products. Now the lumbermen have discovered that the public has a short memory, and may forget about lumber under pressure from manufacturers of other materials.

Were there time for preachment, I should like to say that timber owners should find out more exactly what their timber will yield of various products, according to grades and sizes; also that there is a great field for them to study into the possibilities of diversification of utilization, for, as suggested previously, while lumber manufacture is now and doubtless will continue to be the principal method of timber utilization, a great deal can be accomplished through the diversion of small and inferior timber into other products than lumber. A recent very satisfactory departure in this direction has been the manufacture of hardwood ties of beech, birch, and maple, which, when creosoted, give excellent service. The diversion of much low-grade timber of this character has undoubtedly had an effect locally upon the market for low-grade lumber through the lessening of the supply of this commodity.

No attempt is here made to recite the effect upon timber utilization of plant location, labor supply, taxes, freight rates, and other factors, any one of which may determine whether timber is wasted or saved, and all of which are perennial subjects of discussion among lumbermen.

The modern meat-packing plant, in which every portion of the animal from hair and horns to bones and blood is profitably utilized, has often served as an example to those of us who have visions of the ultimate possibilities of timber utilization, for, intrinsically, every part of the tree would seem to offer as much opportunity for complete utilization as every part of the steer or hog. Some of us, therefore, have occasionally pictured as existing some time and somewhere a great wood-conversion plant, to which will be brought the entire tree, hardwood and softwood, broad-leaf and conifer, and from which will emerge dozens of varied products, ranging from lumber to chemicals, and possibly fabrics and foods, each of which will find a ready market at remunerative prices; but before this can take place present processes must be perfected, others invented, a market created for new products, and heavy investments made with enduring faith in the ultimate outcome.

In the meantime the timber-land owner and the sawmill operator will continue to be guided by the safe maxim that it is "better to waste timber than to waste money."

POSSIBLE ADVANTAGES TO THE STATE OF NEW YORK BY OPENING THE FOREST RESERVES

BY C. R. PETTIS

Delivered before the Society January 9, 1913

I have been asked to speak relative to the "Advantages that would accrue to the State of New York by permitting the sale of timber from the Forest Reserves." There are, of course, disadvantages as well as advantages, but in this discussion I will consider only the latter.

We have in our State constitution a short but very drastic section. It reads as follows:

> "ARTICLE VII.
>
> "SEC. 7. *Forest Preserve.*—The lands of the State, now owned or hereafter acquired, constituting the forest preserve as now fixed by law, shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed."

This section refers to a former statute ("as now fixed by law"), being section 100 of article VII, chapter 332, of the Laws of 1893, which reads as follows:

> "SEC. 100. *Forest Preserve.*—The forest preserve shall include the lands now owned or hereafter acquired by the State within the counties of Clinton, except the towns of Altona and Dannemora, Delaware, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, Oneida, Saratoga, St. Lawrence, Warren, Washington, Greene, Ulster and Sullivan, except
>
> "1. Lands within the limits of any village or city and
>
> "2. Lands, not wild lands, acquired by the State on foreclosure of mortgages made to the commissioners for loaning certain moneys of the United States usually called the United States deposit fund."

The constitution therefore reads as if section 100 was substituted for "as now defined by law." The purpose of omitting the towns of Altona and Dannemora was because the State lands there were largely acquired for the use of Clinton prison at Dannemora.

The history of the development of the forest preserve does not show that the ideas of revenue or realizing the wood growth on this area

ever prompted the movement. As long ago as 1822, when Governor Clinton was building the Erie Canal, the question arose as to the advisability of acquiring the Adirondack forests in order to protect the source of water supply.

In 1872, ten years before the first Forestry Congress, a Commission on State Parks was appointed, and they made an examination and report on the same. About this period large areas were reverting to the State through non-payment of taxes; and, after a period of years, as the lumber industry developed, or as the growth of timber upon the land became sufficiently valuable, it was the common practice of the operator to redeem these lands and acquire title in order that he could secure the timber.

In 1882 Governor Cornell advocated a law which would prohibit the further sale by the State of any land which it had acquired through non-payment of taxes, and in the following year a statute to this effect was enacted. This large area secured, it became necessary to devise some plan of administration, and in 1884 an appropriation was made for a board of inquiry under the direction of the State Comptroller, and a committee headed by Dr. Sargent investigated the conditions in the Adirondacks and made a report. As a result of their work a law was passed in 1885 establishing a Forest Commission. At that time there were 715,000 acres of land acquired by tax sales in the eleven Adirondack and three Catskill counties, which became the nucleus of the present forest preserve. This area was not all contiguous, but in parcels of varying sizes and scattered over an area of about seven and one-half million acres.

In 1887 the so-called Hadley act was passed, which permitted the exchange of isolated parcels of land for those in the central portion of the Adirondacks. In 1888 there was a discussion as to deriving a revenue from these lands. At that time the question of selling timber and bark, also leasing camp sites, was discussed, as was the purchase of land.

In 1890 the establishment of the Adirondack Park was recommended. The purpose was to prescribe certain limits within which the State would purchase land for forest-preserve purposes and lay the foundation for increasing the State's holdings. At the same time an appropriation of $25,000 was made to purchase the land at not more than $1.50 per acre.

In 1892 the Adirondack Park was established, the Hadley act repealed, and a statute permitting the leasing of camp sites was enacted. In 1893 a law was passed permitting the sale of spruce and tamarack

trees over 12 inches in diameter on the stump, or poplar of any size. At this time several camp sites were leased and a revenue of $1,425 per annum was derived.

In 1893 an investigation of the existing commission was instituted, and as a result a new commission was appointed. In 1893 the last Constitutional Convention was held and the present provision was adopted. Prior to that time there was no provision in the constitution relative to the State forest lands. An examination of the debates in the Constitutional Convention indicates that it was the purpose of the framers of this article to preserve this forest and retain it as a protection to the watersheds. From this small beginning the State's holdings in the forest preserve have increased to more than one million six hundred thousand acres.

The statute prescribes a penalty of $10 for cutting trees on State land, and the State officials in charge have no authority to cut any trees. be they living or dead, standing or down, small or large.

During the two decades since the constitution was adopted important economic, industrial, and administrative changes have taken place. At that time there was no appreciation of the importance of scientific forestry; there was not a single American School of Forestry, and probably not more than five technical foresters in the whole country. The forests were not looked upon by the framers of this provision as capable of reproduction and increase, but rather as something whose quantity was fixed. The area has in the meantime increased from 720,774 to more than 1,650,000 acres; our population has grown from six million to over nine million people. It is, therefore, seen that the application was made at a time when there was less than 50 per cent of the present area, only two-thirds of the population, and, furthermore, at a time when the quantity of material tied up was but a small part of the whole, while at present the timber on State lands is a large part of our total forest resource. It is estimated that the amount of standing timber in the forest-preserve region in 1894 was approximately forty billion feet, board measure, and that the quantity has decreased until at present there is not over twenty-five billion feet. At that time it is estimated that approximately four billion feet or 10 per cent was owned by the State, while at the present time the stumpage on State land is approximately twelve billion feet or nearly 50 per cent of the whole stand in the forest preserve, or nearly 25 per cent of the whole stumpage of the State. A change has resulted in the proportion of lumber cut in these sections from about 1 per cent of the stand in 1894 to nearly 10 per cent at the present time.

This provision was enacted at a time subsequent to abundant trespasses and when the administration had not provided proper protection. From the standpoint of protection it is possible to conceive the purpose of those who framed this constitutional prohibition, and that they did what was, probably, then for the public good. It now limits the State in its work, and actually prevents the proper care, preservation, and improvement of the resources which they were so anxious to perpetuate. Forestry schools have been established and technical foresters are available. Private land-owners appreciate the possibilities of better forest management and applying forestry principles in handling their lands, while the State cannot manage, is not deriving any revenue, and secures only indirect benefits from this area one-half as large as the State of Connecticut.

There are enormous investments in mills and industries by private owners; there are also thousands of laborers who depend upon lumbering and wood industries for an income, and in the near future the State's supply must be used or there will be a further decline in these industries in this State.

Not all of the forest preserve is covered with valuable forests, but at least 1,225,000 acres contain merchantable material, some of which is overmature and decaying. If this area were placed under proper forest management it would yield 250,000,000 feet of lumber per year, at $4 per thousand feet, board measure, stumpage, producing a revenue of $1,000,000 annually.

There are approximately 400 miles of camp sites which could be utilized. If one-half were reserved for free use and the remainder rented at a nominal rate an annual income of $1,000,000 could be secured from this source.

The State's direct loss from these two sources of income is therefore two million dollars per year, and this could be secured without depreciating the value of the property.

The material thus secured would amount to one-fourth our annual lumber-cut of the whole State; be equivalent to a quantity secured from clear-cutting 25,000 acres; would decrease the demands upon other land, support established industries, and enable private owners to extend forest management upon their properties.

The value of these holdings is enormous. The lands purchased have proved an excellent investment, and today are an important part of the State's wealth.

The constitution has been construed so rigidly that dead trees cannot be removed; logs cut by trespassers cannot be sold, but must be left

to decay; trees killed by fire cannot be utilized; construction of improved roads across State land or eliminating dangerous curves by deviating from the old-established routes is prohibited.

In extreme cases poor families are paying $20 per ton for coal, while their homes surrounded by State land contain sufficient fuel that is going to decay. There are also large power developments which are prevented because some State land (not necessarily forest) will be overflowed. Some of the land is cleared, cultivated, and occupied, and in some cases these areas could be better used for agriculture than forestry.

To literally carry out the intent of the constitution and "forever keep as wild forest lands" might prohibit the reforestation of over one hundred thousand acres of these lands which cannot be placed under forest cover except by artificial means.

THE ACQUISITION AND USE IN WISCONSIN OF STATE FOREST RESERVES

BY E. M. GRIFFITH

Delivered before the Society January 9, 1913

Twenty-five years ago Wisconsin was one of the greatest and wealthiest forest regions in the United States, and the twenty-seven counties which comprised the northern portion were practically an unbroken forest extending from Michigan to Minnesota. Even as late as 1900 Wisconsin ranked first among the States in the production of lumber, but in 1910 it had dropped to eighth place, with a decrease of 45 per cent in production, which is much greater than that of any other State.

The axe, followed by terrific forest fires, has depleted the great forest wealth, and when it is almost too late the State is waking up to appreciate something of the value of this wonderful natural resource which it has dissipated so recklessly, and is making an effort to save the forests which are left.

As early as 1867 a law was passed in Wisconsin providing for the appointment of three commissioners to investigate and report upon the injurious effects of clearing the land of forests, the duty of the State in regard to the matter, and an exhaustive and very valuable report was published by the three commissioners, but no results were accomplished. In 1897 another law was passed providing for the appointment of a forestry commission of three members by the Governor, who were to draw up a plan for the protection and utilization of the forest resources of the State, and for the organization of a forestry department and the creation of a forest reserve.

The commissioners' report, including a draft of a bill which they recommended for passage, was published in 1898, but no legislation resulted until 1903. The forestry law of 1903, however, was very defective, and the first real and effective forestry legislation was not accomplished until 1905. Under the law of 1905 a non-political State board of forestry was created, and it was provided in the act that the State forester to be appointed by the board must be a technically trained forester, and certified as such by the Secretary of the United States Department of Agriculture. The most important provision of this law was that all State lands in the northern, or timbered, portion of the State were set aside for forestry purposes, and that the agricultural and

scattered lands could be sold by the board, the proceeds to constitute a "forest reserve fund" to be used in purchasing lands suitable for enlarging the forest reserve area. Through the forestry law of 1903 some 40,000 acres of land at the headwaters of the Chippewa River were set aside as the nucleus of the forest reserve, and the law of 1905, by including all State lands in the northern portion of the State, immediately increased the area of the reserve from 40,000 acres to over 300,000 acres, and through purchases of privately owned lands, at an average cost of about $3.32 per acre, the total acreage of the forest reserves is now 390,000 acres.

The 340,000 acres of State lands which by 1905 had been set aside for forestry purposes were scattered through all the northern counties of the State, and it was necessary to have all the lands which were not within the area which had been selected for the permanent forest reserve carefully appraised and then placed on the market.

During 1911 and 1912 about 36,000 acres of land have been sold for approximately $121,000, and practically all of this amount has been used in purchasing lands to block up the forest reserves. It is felt that satisfactory progress has been made in increasing the forest reserve from 40,000 acres to 390,000 acres in eight years, but Wisconsin has only made a good start, as the State must have a reserve of at least 1,500,000 acres in order to protect the headwaters of the most important rivers, aid in supplying the wood-using industries with the timber which they must have, and to protect the beauty of the wonderful northern lake region that should annually bring millions of dollars into the State through tourists, campers, hunters, and fishermen.

The creation of the "forest reserve fund" was a wonderfully wise move, as it has encouraged the sale and settlement of agricultural lands, and has given the forestry board a steady income with which to increase the reserve, and also provide for its protection and management. In order to further expedite the purchase of lands to block up the reserves, the legislature in 1911 made an appropriation of $50,000 a year for five years, but this amount is entirely inadequate and must be largely increased.

State Forest Policy.

What specific objects has Wisconsin in view in creating her forest reserve? The State is building up her reserve in some of the most northerly counties, viz., Forest, Vilas, Oneida, Iron, and Price, and within this area there is not only a wonderful lake region of over 1,200 lakes, but

also the headwaters of four of the greatest rivers in the State, viz., the Wisconsin, Chippewa, Menominee, and Wolf.

The State lands set aside for the reserve, as also the lands purchased, are not suitable for agriculture, being either too sandy, rocky, or swampy, but these lands have grown some of the finest pine timber in the State, and all the young timber needs is protection from fire. The State forest policy, then, is looking to the accomplishment of the following points, viz:

1. The protection of extensive forests upon the headwaters of four important rivers. This, together with the use of many lakes as storage reservoirs, will tend to make the flow of these rivers unusually regular, thus preserving, and even improving, many water-powers which will become increasingly valuable, especially since Wisconsin has no deposits of coal.

2. Supplying the wood-using industries of the State with a considerable amount of timber, and thereby, it is hoped, keeping many of them within the State.

3. Preserving the forests in the beautiful lake region of northern Wisconsin will both protect and greatly enhance its present attractiveness as a resort region for not only the citizens of the State, but of the entire Mississippi Valley as well. The value of such a resort region is not generally understood, even from the dollar viewpoint; but the report of the Bureau of Labor of New Hampshire for 1905 shows that the resort business yielded in that year over $10,000,000, and the report of the Forest, Fish, and Game Commission of New York for the same year states that it was over $7,000,000.

The following tables show the amount of the summer resort business within the forest reserve area of Wisconsin for 1912:

Number of resorts	91
Number of buildings	639
Number of guests that can be accommodated at one time	4,372
Number of guests accommodated in year	13,131

GROSS RECEIPTS

Board and room at resorts	$356,025
Railroad and Pullman fares	157,572
Hotels, liveries and boat liveries	29,537
Hunting and fishing licenses, guides, etc	131,310
	$674,444

During 1911 and 1912 the State received only $261 from leasing camp and cottage sites within the forest reserves; but this use of the re-

serves is just beginning to be understood, and as a large number of applications are now being received, it is expected that the receipts from this source will increase very rapidly.

4. The young timber on the reserve will be protected and denuded areas planted, so that in future years the State will receive a direct and increasing revenue from the sale of mature timber.

If Wisconsin had been as wise as Canada and retained its timbered lands instead of selling them, the forester would have a going concern and the timber would be his stock, which he would sell as it became mature, and thus be able to show a revenue at once. But Wisconsin chose in the past to sell its timber lands to any one and every one at a fraction of what their present value would be, and therefore the State must buy back the timber lands that it sold, only now thousands of acres have been cut over and burned, and hence it will be many years before there will be much merchantable timber to sell. The bright side, however, is that much of the timber that was left is now, with increasing demands, becoming valuable. It is impossible to foretell what timber will be worth twenty-five or fifty years from now; but it is at least safe to say that it will be worth as much as it is today. In 1911 and 1912 the State sold $39,000 worth of timber, and also received $517 for hay and $163 for cordwood. Sales of timber will not be made except where it is badly burned or is really mature and should be cut.

Creation of Storage Reservoirs.

Wisconsin has adopted the policy of allowing river-development companies, under the most careful State supervision, to use many of the lakes at the headwaters of the Wisconsin and Chippewa rivers as storage reservoirs, so as to hold and store up the excess or flood waters, and then draw upon the reservoirs in times of low water, when the water-powers upon these rivers are in great need of more power. No new storage dam can be built without the consent of the State Board of Forestry, and the board also controls the level to which the water may be raised or lowered, so that the beauty and attractiveness of these lakes for summer camps and cottages will always be carefully protected. With a large forest reserve surrounding these lakes and thus preventing the deep snows from melting too rapidly, and the lakes as storage reservoirs holding back the spring freshets, the stream flow of the Wisconsin and Chippewa rivers can be systematically regulated, and thus the water-powers will gain enormously from a constant and even flow. Wisconsin has gone much farther than the other States in developing a definite policy looking to the full development of storage reservoirs, and the forest reserve will always protect the reservoirs from silting up.

Wood-using Industries.

In 1910 a study of the wood-using industries of Wisconsin was made in coöperation with the United States Forest Service, and it was found that more than 930 million board feet of lumber, valued at $20,000,000, is annually utilized in the wood-using industries, and that already almost 50 per cent of this lumber is purchased outside of the State. This means that in time the State will lose its wood-using industries unless the rapid destruction of the forests is checked. A State forest reserve of 1,500,000 acres can aid very materially in supplying this raw material, though the State cannot and should not be expected to do it all.

The Forest Reserve as a Summer Resort.

The State Board of Forestry has adopted the policy of leasing camp and cottage sites upon the shores of the beautiful lakes within the forest reserve. Owning several thousand acres of land upon the shores of some of the most attractive lakes in Oneida and Vilas counties, the State is easily able to meet all present demands and can lease sites to suit almost any taste.

From 10 to 20 acres will be leased to one person or family, and as much more to a club or association as they may really need. Leases can be given for a period of twenty years, with the privilege of renewal, and the yearly rental will vary from $10 to $50, according to the size of the lot required, its location, and the amount of timber upon it. The contract between the State and the lessee is very simple, merely providing that the lessee will cut only such timber as is marked for cutting by the forester, pay the local price for such logs as he may use in building, use all possible care in building fires, agree not to sell liquor on the premises or to sublet without the consent of the board. For a small additional sum, merely sufficient to cover the cost, the forest rangers will look after a camp or cottage during the winter months or while the owner is away.

The forest-reserve region should become in time a great summer resort for people throughout the entire Mississippi Valley, as it has a fine, bracing, dry climate, pine forests, and sandy soil, and is blessed with many of the finest chains of lakes in the entire country. Vilas county in particular has a greater area of water than land, and long trips can be made by launch or canoe. There is plenty of sport for hunters and fishermen, and the resorts furnish good beds and excellent meals at reasonable prices.

The board is anxious to encourage the best utilization of the forest reserve as far as possible, and it is believed that the forest-reserve

region, especially in Oneida and Vilas counties, is far more valuable for development as a great resort than for any other purpose, and if this area is protected and everything done to make it attractive, it will mean lasting prosperity for all the residents of that section.

Grant of Islands from the Government.

Due to the untiring efforts of Hon. E. A. Morse, in the House of Representatives, and Hon. Robert La Follette, in the Senate, the United States Congress, on August 22, 1912, granted to Wisconsin all the unsurveyed and unallotted islands in inland lakes north of township 33. The islands are granted to Wisconsin as an addition to the State forest reserves, and the act provides that they must always be managed as part of the reserves; otherwise they will revert to the United States.

Before this grant a large number of islands had been acquired by private parties, and in many cases they had cut off all the timber, leaving the islands eyesores instead of the beauty spots that nature intended them to be.

The Government did not have an accurate record of the number of islands in the inland lakes, but the reports of the State forest rangers show that there are about 250 islands, and that they contain all the way from three-quarters of an acre up to 40 acres each. During the winter of 1912–1913 it is planned to have all these islands carefully surveyed and described, and they will then be leased for summer camps and cottages in exactly the same way that lake-shore property within the forest reserves is leased by the State.

Wisconsin is extremely fortunate in securing such a large number of beautiful islands, and they will greatly enhance the beauty and value of the forest reserves.

Proposed Game Preserve.

It is proposed to fence in some 8,000 to 10,000 acres of land in 41, 7 E., within the heart of the State forest reserves, as a game preserve, and to inclose within this preserve elk, moose, deer, pheasants, grouse, and such fur-bearing animals as beaver, mink, otter, and so forth.

The State already owns the land that it is proposed to inclose, and the Government is prepared to give the State elk from the big herd that winters in Jackson's Hole, Montana, and in which many of the animals die each year on account of the lack of feed.

Some game enthusiasts have also offered to assist the State in securing some moose, and a gentleman will give a large number of Mongolian pheasants. Native deer can readily be driven into the game preserve, and the fur-bearing animals can be secured within the State.

It is also proposed to use the game preserve and possibly large marshes within the forest reserve as a wild-fowl refuge, where migratory birds will have a chance to breed without being slaughtered.

Edward A. McIlhenny, of New Orleans, has established some splendid wild-fowl refuges on the coast near New Orleans, and largely through his efforts Mrs. Russell Sage, of New York, has recently purchased Marsh Island, near New Orleans, and has presented it to the Government to be held for all time as a wild-fowl refuge.

Mr. McIlhenny is a true sportsman who is working to preserve the wild-bird life of America, and he is meeting with great success in his efforts to have all the States along the Mississippi River set aside wild-fowl refuges so that the birds in their flights may find protective areas from New Orleans to the Canadian line.

The main idea of the proposed game preserve near Big Trout Lake, in 41, 7 E., is to protect the elk and moose until they increase to sufficient numbers so that some of them can be set free within the forest reserves in Vilas county, and to then ask the legislature to prohibit the killing of any elk or moose for a number of years. In this way it will prove possible in a few years to again have these splendid game animals in Wisconsin, and the deer within the preserve should increase so rapidly that a number of them could be liberated each year.

The game birds will, of course, fly from the fenced area to other parts of the forest reserve; but they will very quickly learn where they are not shot, and will return to the preserve during the breeding season or when shot at frequently.

The fur-bearing animals should gradually be distributed through all the lakes and streams of the forest reserve, and their taking carefully regulated so that they will not again be nearly totally destroyed.

Such a game preserve is the only feasible way of stocking the forest reserve with the game which it should contain, and now that the State owns the land the chief cost will be the fencing, and that can be purchased for about $100 per mile.

What the State Forest Reserves Offer to the Consumptive.

The State forest reserves, comprising some 400,000 acres, and lying within the wonderful lake region of northern Wisconsin, should be used and enjoyed to the fullest extent by all the people of the State, and one of the best possible uses to which a portion of the reserves can be put is as a big outdoor sanatorium for convalescent consumptives and those who are threatened with the disease. The State Board of Forestry now has one large forest nursery containing some 2,500,000 tree seedlings,

and within a year or two other nurseries will be built, so that probably the annual production of the nurseries will be about 2,000,000 seedlings, which will be nearly sufficient to reforest 2,000 acres a year.

Work both in a forest nursery and in planting the seedlings is light work, which can be arranged so that it would be especially suited to the weakened condition of a convalescent consumptive patient. It is proposed to ask the legislature for an appropriation of $10,000 per year, which would cover the cost of building and keeping in repair the wooden shacks in which the patients would live, and also the salaries of a doctor and nurse. The State Board of Forestry would set aside the land required for the sanatorium, forest nurseries, and tracts to be reforested, and would pay the patients for the time in which they were actually employed in working for the State.

At first a patient might not be able to work more than four hours a day, but at 15 cents per hour he would have earned 60 cents, or more than his board for one day would cost, and all that he earned over and above the cost of his board would be credited to him, so that when cured he could leave the sanatorium with at least a small amount of money to start life anew.

Wisconsin has a splendidly equipped consumptive sanatorium at Wales, but Dr. Coon, the superintendent, as well as other doctors of the State, find that the hardest problem is to find light outdoor work for the convalescent patient. Many of these are men and women from the larger cities, who, on account of their very slender means, are obliged to return at once to their work in the factory or store, and the long hours, combined with lack of fresh air, frequently result in a serious relapse and sometimes death.

For these reasons the doctors have welcomed enthusiastically the plan of giving these convalescents a few months at least of steady outdoor life on the forest reserves, combined with light and pleasant work.

Some patients will undoubtedly find that in order to avoid a relapse they must continue to live in the cool, dry climate of northern Wisconsin, and in such cases the State Board of Forestry could lease to them at very reasonable rates small tracts of arable land near the public resorts, hotels, and private camps, and the patients would find that they would have a ready sale at good prices for all their vegetables, milk, chickens, etc. There are also thousands of men and women workers in Wisconsin who, though not consumptives, are so run down and worn out that they are an easy prey to the disease. It is a good, sound policy for the State to aid such people in regaining their health, and thus avoid their becoming public charges, and the State could well afford to allow

them to build camps on many portions of the forest reserves, and also to give them work in reforestation to a very considerable extent.

As a few months' outdoor life in the bracing climate of northern Wisconsin will often make certain the complete cure of the convalescent consumptive, and also ward off possible consumption from the weak and debilitated worker, and as the State must reforest its denuded lands which are unfit for agriculture, it would seem both a sane and humane policy to give the patient a chance to do the work for which he is so suited, bringing to him health and to the State wealth through the forests which will be grown.

Forestry by Private Owners.

Up to the present time very little real forestry management has been practiced by lumber companies, large timber-land owners, or private individuals, and this has been largely due to the danger of timber lands being destroyed by forest fires, and also the annual taxing of growing timber which has encouraged forest destruction instead of forest conservation.

Many of the large wood-using industries of the State, especially the paper and pulp mills, should own large tracts of timber and operate under a systematic plan of forest management, but many are held back from doing this on account of the fear of fire and taxes. The first can and will be overcome through education of the people to the fearful and needless losses from forest fires, together with well-organized forest-fire patrols; and the second obstacle will be removed when the State appreciates that the present system of annually taxing growing timber is archaic and that it directly encourages and even forces forest destruction.

Wisconsin, with a total area of about 36,000,000 acres, has, in the northern portion of the State, probably 3,000,000 acres unfit for cultivation and which should be held permanently under forest growth. Fortunately most of these true forest soils are at the headwaters of some of the most important rivers, and therefore the protection of the forests on these areas will not only insure a considerable supply of timber, thus aiding very materially in perpetuating the wood-using industries of the State, but will also insure a more nearly uniform stream flow, and thus conserve the very valuable water-powers of the State.

The College of Agriculture of the University and the State Geological Survey are making a detailed soil survey of the northern and less settled portions of the State, and it is thought that when the areas of non-agricultural land are definitely determined the owners will begin to seriously consider the protection of the young timber on such lands, and even planting them if this is found necessary.

EXPERIMENTAL FOREST PLANTING IN THE HAWAIIAN ISLANDS

BY RALPH S. HOSMER

Delivered before the Society October 24, 1912

My purpose in proposing to speak before the Society of American Foresters at this time was to outline briefly certain problems in experimental forest planting that are now confronting the Territory, with the idea that in the discussion light would be thrown on some points that are giving us trouble. In order to make a background, as it were, against which I can sketch more clearly these particular questions, I shall first attempt to give you an idea of the general forest situation in the islands and the part that forestry has to play there.

The Territory of Hawaii consists of eight main islands which lie just within the tropics. Honolulu is 2,100 miles southwest of San Francisco, a five and a half days' trip by a 15-knot steamer. Each of the islands consists of a high mountain mass rising from 4,000 feet as on Oahu, and 5,000 feet on Kauai, the northern island of the group, to 10,000 feet on Maui and to not quite 14,000 feet on Hawaii, the biggest island and the most southerly.

The Hawaiian Islands, lying in the belt of the northeast trade winds, have on their windward side areas of very heavy precipitation. The trade winds bring the moisture-laden clouds, which pile up against the high mountains, for in almost every case the mountains are high enough to obstruct, if they do not absolutely stop the clouds from going over; with the result that on the northeast side there is a precipitation which in places runs up to as high as 300 inches per annum, and in one or two spots even up to nearly 400 inches. On the other side of the mountain, on the contrary, particularly on the Island of Hawaii, where the mountains, being almost 14,000 feet high, absolutely shut off the trade-wind clouds from the lee slopes, there obtain conditions almost of aridity. Thus, in places on the lee slope of Mauna Loa there are probably not more than five or six inches of rainfall per annum, at most not more than 10 inches. Furthermore, as the islands rise steeply from the sea, there are marked changes in temperature as one goes up, and hence, of course, differences in the characteristic vegetation at the several elevations.

The main industry of Hawaii is the raising of sugar-cane. The average crop from the fifty-odd plantations which are in operation is now

somewhat over five hundred thousand tons per annum. Sugar-cane is for the most part a very profitable crop. If one makes money at all he makes a great deal. Thus, while some of the plantations have never paid any dividends, others pay from 12 to 18 per cent per annum. The average for the Territory as a whole is, however, about 5 per cent.

Some of the very best land for sugar raising lies around the slope in the section which does not receive sufficient rainfall to grow cane. Here it is necessary to resort to irrigation. Over half of the sugar-plantation area is irrigated artificially, so that about two-thirds of the sugar produced annually is the result of irrigation. This has led to extensive irrigation works being inaugurated and put into effect by the sugar-plantation companies. Altogether about fifteen million dollars of private capital has been so invested. One of the big ditches on the Island of Maui, for instance, is 45 miles in length. Two other ditches, not quite so long, parallel, one above and one below this big ditch. It is now planned to dig a ditch on the Island of Hawaii, the so-called Kau ditch, which will carry water a distance of over 90 miles.

With the steep, short watersheds, heavy precipitation, and liability of erosion it is essential that a cover of vegetation be kept on the slopes to insure a constant and steady supply of water. For this reason the Territory is making forest reserves, essentially protection forests, on the catchment areas, to protect the streams which feed the irrigation ditches. There have now been set apart 27 forest reserves, with an aggregate area of 683,101 acres, of which 67 per cent (454,390 acres) is land belonging to the Territorial Government. The forest reserves in Hawaii are somewhat in the case that the National Forests were 15 years ago. They appear on paper and officially have been set apart by proclamation of the Governor, but as yet they have not the efficient system of administration which they need and which it is hoped later to secure. However, through the coöperation of individuals, and especially of corporations, whose interests in this matter are identical with those of the Territorial Government, a good deal is being done in protecting and administering the forest reserves. Later it may be possible to have all the administrative work directly under the control of the territorial officials.

The custom in making forest reserves in Hawaii is to draw a boundary line around the area which in the judgment of the territorial forester should be so set apart. This line may include both government and privately owned land. Public hearings are then held, under the law, and a chance given for objection. Then, unless there is serious objection, the Governor sets apart by proclamation as a forest reserve the land belonging to the Territory. If the land is under lease, it is set

apart subject to the existing lease. The private land included in the forest-reserve boundary is not actually taken over unless the private owner wishes to transfer it to the Board of Agriculture and Forestry, which he may do under the law. He is not obliged to do this, but as most of the large, privately owned forest tracts are held by sugar-plantation companies, in practice there is a good spirit of coöperation in caring for the forest.

All told, there are in Hawaii about one million acres of native forest. It is expected that eventually about three-quarters of a million acres will be included in the forest reserves, of which about 70 per cent will be Government land. There are still three or four big reserves to be created, one on the northeast end of the Island of Hawaii, which will considerably swell the present total area and bring it up to about the figure named.

The native forest in Hawaii consisted of three principal types. First the lowland type, extending along the shore and up to an elevation of about a thousand feet. This has pretty much given way to agricultural land, and except in a few spots the trees of the shore zone have practically disappeared. The original lowland vegetation, too, has been replaced in spots by the introduced Algaroba forest, the mesquite of the Southwest, which was brought to the islands by one of the early Roman Catholic priests, and from a single tree in Honolulu has now spread over the lee side of each of the islands till it covers from 50,000 to 60,000 acres. Algaroba is a very important tree locally for three reasons. It is used for fuel—the wood sells for from $10 to $14 a cord; it is also good as a bee pasture; and, third, the pods are a very important source of stock feed. The tree develops very much better than it does in the Southwest. It gets to be a good-sized tree in Hawaii—as high sometimes as fifty or sixty feet, with attractive form—spreading and deliquescent. Algaroba will not grow, however, on the windward side of the islands, in the area exposed to the trade winds.

Of the native forest, the second belt stretches from above the land cleared for agriculture, say from 2,000 to 2,500 feet up to about 6,000 feet. In the section watered by the trade-wind rains the predominant tree is the Ohia lehua (*Metrosideros polymorpha*). No exact figures are available, but probably from 65 to 70 per cent of the total number of trees in the native forest are of this species. There are several forms of ohia, but whether or not they are botanically distinct has not yet been worked out. There are a good many other trees of slight economic value, except that they form a dense forest. With the trees, an undergrowth of ferns, shrubs, and climbers, with moss on the surface, makes

a pretty nearly ideal cover for a watershed. In the upper part of this rain-forest is normally the home of the koa (*Acacia koa*), between the elevations of five and six thousand feet.

Getting above the trade-winds region, up into the upper strata where the rain comes from chance clouds, there is a third forest zone on the higher mountains, particularly on Mauna Kea on Hawaii and Haleakala on Maui, where another tree, the mamani (*Sophora chrysophylla*) makes in places an open forest. The wood is locally valuable for fence-posts, being very durable in the ground; otherwise it has no special importance. Timber line is about 10,500 feet. There are numerous small shrubs at that elevation. Higher up one runs into a sandy soil, with little vegetation of any kind. On Mauna Loa on Hawaii, which is of recent geologic origin, there is hardly any vegetation above 8,000 feet.

I regard the native forest, particularly the rain-forest type, as being of two classes: first, the water-bearing forest, and, second, what I have termed the "commercial forest." About nine-tenths of the forest proposition of Hawaii is a protection forest problem, pure and simple. Water is the important product, not wood, and everything is to be subordinated to keeping the forest intact in its primeval condition, so that just as much water can be got out as possible. What is needed is simply to leave the forest alone, keeping man and animals out.

The Hawaiian forest is peculiarly susceptible to injury. Even a few cattle grazing for a short time will work a great deal of damage. Practically all the species composing it are shallow-rooted and secure their plant food from the upper layers of the soil. When the undergrowth is destroyed by cattle, the trees are unable to adjust themselves to the changed conditions and most of them die. Then a rank-growing, introduced grass gets in and prevents reproduction, and the forest disappears in very short order. To insure adequate protection to the watersheds it is absolutely essential that the forest be kept intact.

As to the commercial type: there are some areas, particularly on the lee side of Hawaii, where there is no permanent running water, due to the geological formation, these districts being new lava country. The whole of the Island of Hawaii is incredibly porous. For example, along the lee coast there are no permanent streams for a distance of 200 miles or more. Here, obviously, watershed protection is unnecessary, and the wood that can be got from it gives the principal value to the forest. Ohia has been developed both for railroad ties and also, and now principally, for interior flooring and wainscotting. Koa is exclusively a cabinet wood. Both should find a better market than they yet have.

The practice of forestry in the Territory of Hawaii falls under one or

the other of two general divisions: first, the creation and administration of forest reserves, and, second, tree planting. The forest work of the Territory is carried on by a Division of Forestry under a Board of Agriculture and Forestry. The appropriation amounts to about $14,000 per annum, fluctuating somewhat from year to year. The creation of forest reserves has been the chief work of the local forest service since it was established ten years ago. The first and most important forest problem facing the Territorial Government in Hawaii was to get set apart and put under administration the area of native forest needed to protect the watersheds. The second main line of work is tree planting.

Tree planting has gone on more or less actively in Hawaii for the last thirty years. As the native forest has been pushed back, the demand for fuel wood on the plantations has increased, as has also the need for wood for various structural purposes. All of the native Hawaiian forest trees being hardwoods, suitable primarily for cabinet work rather than structural purposes, all of the construction timber used in the islands is brought from the mainland. Douglas fir and redwood are imported in large quantities every year.

Tree planting in Hawaii, so far as it has yet been practiced, was largely developed to supply minor needs, such as for posts, ties, and bridge timbers. For this purpose there are being used six or eight species of eucalyptus. Other trees commonly planted are the Australian ironwood (*Casuarina*), the Japanese cedar (*Cryptomeria japonica*), and the Australian silk oak (*Grevillea robusta*). These trees are being planted in various places in the Territory and will more and more be used for supplying fuel, ties, posts, as well, later, as timbers for bridge timbers, rough lumber for concrete boxes and flume construction. In connection with local irrigation a great deal of water is used on the windward side of the islands for transporting the cane to the mills, by means of flumes. This requires long trestles across deep gulches. Large quantities of timber are so used, and as these trestles have to be renewed at frequent intervals the timber item is no small one.

The ironwood (*Casuarina*) is used primarily as a windbreak in places exposed to the salt spray along the seacoast in Hawaii. There is now a belt practically all the way for 30 or 40 miles—one plantation after another—which enables sugar-cane to be grown down much closer to the bluff than otherwise would be the case. I am told that it increases the yield in these lower fields by about a ton. On a low-tonnage plantation—four or five tons to the acre—an increase of half a ton to the acre, or sometimes even more than that, is an item that is distinctly to be considered.

The Japanese cedar has a wood very much like redwood. It is used by the Japanese for all round purposes, much as we use redwood. It is going to be an extremely valuable tree in Hawaii. This tree does best at from one to three thousand feet, especially in wet places not exposed to the wind.

Tree planting was started by private sugar plantations and by certain individuals. It has also been carried on in a more or less sporadic manner by the local Government from as far back as the time when the islands were a monarchy. During the last nine years not so much Government planting has been done because the money devoted to forestry has been used more in other ways, but in the last two or three years planting has begun again on Government land.

The efforts of the Division of Forestry in assisting forest planting have consisted in the giving of advice as to what kinds of trees to plant to get certain desired results, and how to do the work. The idea embodied in the old Forest Service Circulars 21 and 22 has been in force. Further, there is maintained at Honolulu a Government nursery where seedling trees are grown and sold at cost price, or given away during frequent periods of free distribution. Arbor Day serves, too, as a convenient excuse to push tree distribution, but for the most part the trees are sold at cost price. This, I think, is a much better plan than giving them away free. While we encourage the establishment of local nurseries by sugar-plantation companies, a good many companies have preferred to buy small seedlings from us and do their own transplanting. By encouraging tree planting in these ways the total number of trees set out per annum has in the last five years materially increased.

Hawaii has one advantage over eastern States in that in the islands tree seedlings can be got ready for planting in a short time. In the case of the eucalypts it is a matter of about four, or at most six, months from the time of seeding to planting out. With the ironwood about the same. The Japanese cedar takes about one year. The eucalypts are grown in flats, after the general custom in use in California. In addition to the forest trees a good many flowering and ornamental trees, as well as shade trees for street work, are grown at the Government nursery and given to city improvement societies and others.

Coming now to the points I wanted especially to talk about, I wish to place before you briefly an outline of certain of the problems we have confronting us in the way of experimental forest planting, with the idea that it will lead to discussion, because there is a whole lot of light to be got on this subject and I want to get some from this company.

As I have already outlined, in talking of the topographic and climatic conditions in Hawaii, there is a very considerable range of localities and conditions under which we have to plant. In an incredibly short distance one gets absolutely different climatic conditions. Places almost within a stone's throw of one another will have in the one case heavy rainfall, in the other conditions of aridity. For instance, in Honolulu, which is on the south side of the range, the rainfall in the town is about 37 or 40 inches. Going up to the Pali, which is less than five miles away, a gap through the mountain range, the rainfall is 125 inches. As one goes up the other mountains he gets equally abrupt changes in rainfall and temperature.

For this reason we have in Hawaii something like 10 or 12 typical districts, varying from one another, for each of which it is necessary to find the one or two trees best adapted for forest planting. One or two species is enough for each place, but we have to find the most suitable tree for each locality. To do this we are attempting, as far and as fast as our limited funds will allow, to try out trees of economic importance from different parts of the world. So far, certain of the eucalypts, the ironwood and the cryptomeria, seem to be the best adapted to our needs. Very possibly we can find something which is still better. If so, we distinctly want to get it. This is for the lower level. Then, above an elevation of 7,000 feet, where the native rain-forest peters out, under conditions apparently not at all dissimilar to southern California—sandy slopes and similar climatic conditions—there seems to be an admirable chance to bring in some of the temperate-zone trees, particularly pines and other conifers.

The object of all the tree-introduction work has, of course, in the end a direct economic bearing. At the lower elevations trees are needed as far as may be the wood wants of the plantations. There is no supply to be had from the native forests because Hawaiian trees do not yield construction timber, while the cost of timber imported from America is bound to increase year by year. On many plantations, too, the question of fuel supply is a serious one.

At the lower elevations tree planting will be done on areas unsuited for agricultural crops, such as gulch sides, field corners, and the like, or on rocky land that cannot be used to advantage for other crops than trees. On the upper slopes of the high mountains it is a problem of putting to wise use land that at present is of only the most indifferent value for grazing. Wood is needed; the land to grow the trees is available; the problem is to secure the right trees. To find out what trees

are the best, the most practical method seems to be the establishment of experimental plantations, where species new to the islands can be planted, cared for, and watched.

The tree planting which has been done by private individuals during the last 30 years has been rather unsystematic, as one would naturally expect it to be. The people from the islands in traveling have been in the habit of bringing back seeds and plants from different parts of the world and putting them out, usually promptly losing the names in the process. For this reason Honolulu is a good deal like an unlabeled botanic garden. A good many of the plants so far introduced are ornamentals. Of the economic trees the choice has narrowed down practically to those already named.

It is difficult to get private individuals or corporations to carry on systematic experimental work. Commercial organizations naturally want something they know is going to succeed. Experimental work unfortunately very often leads to a good many failures with few successes. There are, however, in the Territory a few individuals interested in experimental tree planting. One is a ranch manager on the slopes of Mt. Haleakala, who is planting groups of trees for stock shelters. He has tried out a good many kinds of eucalypts; from these groves we shall get very valuable data. One or two other persons have done similar work. But for the most part experimental forest planting will have to be carried on by the Territorial and Federal governments. The funds of the Territorial Government being more urgently needed in other directions, it has not been possible to devote very much money to experimental work. Beyond having the time of one or two laborers in the nurseries taking care of new things, and some small sums for planting out, I have not been able to get the amount of money I think ought rightly to be devoted to this phase of the work.

However, we are going ahead as fast as we can. The Federal Government, through the Forest Service, has for the last four years given allotments for experimental planting, primarily on the high mountains, though lately we have been using part of the money for tests of eucalyptus at the lower levels.

On two of the higher mountains, Mauna Kea and Haleakala on Hawaii, we started out by putting three plots in series at elevations of seven, nine, and eleven thousand feet, and afterward one more, at eight thousand feet, a little further around the mountain, and on Maui at seven, eight, and nine thousand feet. The idea was to start at these points, in fenced-in five-acre-plots, certain things that gave promise of doing well and see what came of it. Later, if these plants proved a

success, other spots could be started elsewhere on the mountain. The plots were fenced in and the work got under way. To save time, shipments of seedling trees, conifers (Coulter and Jeffrey pines, incense cedar, and western yellow pine), were sent down from the Forest Service nurseries in California. Afterwards I got from the D. Hill Company, by express, certain other conifers, western yellow pine, and an assortment of six or eight other conifers that I thought might do well.

The results of these experiments of bringing plant material from the mainland did not prove a success. The seedlings got to Honolulu all right, in first-rate condition, both from California and from the Hill Nursery, but in the transshipment to the other islands there was some necessary delay. The local boats only go twice a week and sometimes only once a week, and the ships from the coast frequently come in the day after they have gone. Then there is the long haul up through the hot lower country, so that by the time the seedlings were delivered at the planting ground they were not in good condition.

We have since been able to establish local nurseries. We intended to do so at the start, but there were various hindrances in the way. Apparently things were pretty well fixed for coöperation with two of the ranches which were carrying on forest work, but when the plan came to be put in practice mechanical difficulties developed, so that we were very much hampered in getting results. But we have now some seedlings coming on in local nurseries which I hope to put out personally a little later.

I also planted considerable quantities of seed collected by the Forest Service on the western forests, and also some seed purchased from eastern concerns. At first I tried out a good many things which flatly did not do well at all, among them some of the broad-leaved trees from the eastern part of the United States, under the impression that the conditions were not quite so unfavorable as they afterwards proved to be. As yet it is too soon to tell positively about the conifers, but with a number of species the percentage of seedlings that germinated and lived through the first season is sufficiently promising to be really encouraging.

The purpose in sowing tree seed direct was to find out if the seed-spot method was at all practicable under the conditions obtaining in Hawaii and to get an additional line on the behavior of the species tried. No very large returns were expected, but as the cost of sowing the seed was very little, it was felt that the effort was justifiable.

Seedlings of the following species were found, among others, to have germinated and apparently to have started to grow in a number of the

plots, both on Maui and on Hawaii: *Pinus coulteri, contorta, ponderosa, murrayana, insularis, sylvestris, radiata, Cupressus arizonica, Libocedrus decurrens, Picea engelmanni, P. parryana,* and *Pseudo-tsuga taxifolia.*

It seems to me now that for the planting of these upper slopes, where the rainfall is scanty, there should be used some one or more species of conifer from the Southwest, or possibly even from the Mexican mountains, if we can get the seed of such trees. I think by trying this seed in seed-spots and also by starting in a nursery and planting out seedlings we may be able to establish one or two species on these high slopes. If so we shall have been justified in pushing the work ahead. I wish to bring this matter up for discussion, because I want to get suggestions as to particular trees which any member of the Society may have to recommend, as well as suggestions as to desirable modifications of method.

For the last two years a portion of the Forest Service money given Hawaii has been diverted from the planting on the high mountains and used in establishing plantations of eucalypts in Nuuanu Valley, near Honolulu. The place is near the city, within the area set apart for water-supply purposes. We have already planted there some 20 species in plots of about half an acre each, the trees set six by six. The kinds tried are species supposed to be of economic importance, eucalypts new to the Territory. In the autumn of 1912 we expect to put in another block of as many more kinds. Our idea is that if we can establish these plantations and keep them up for some time we can find out which of these different species are best. And then, later, by establishing similar plots in other localities throughout the islands, and showing private owners that particular kinds are good at certain places, we can induce them to plant, on a larger scale, trees that in the long run will yield excellent returns. The proposition in Hawaii is that, with the native forest trees being unsuitable for structural purposes, and with the increasing price which is bound to come for timbers imported from the mainland, even an inferior timber tree can find a very good market, let alone its use for fuel. If a tree grows at all and develops any sort of shape, we are practically sure of a market for the wood at a price which will a good deal more than repay the cost of planting, while if it develops clear, good wood the return ought to be extremely profitable.

The eucalypts which do grow well in Hawaii grow very well indeed. So far we have demonstrated that about six kinds are well adapted to local conditions. The blue gum (*Eucalyptus globulus*) is of course the fastest growing of the eucalypts. It does best with us from about two to five thousand feet. At 4,000 feet I have seen a small but typical

stand which was as good as any I have ever seen in the Sacramento Valley. The trees were 125 feet tall and from 16 to 18 inches in diameter, all in 14 years. At the lower elevations the blue gum does not succeed. *Eucalyptus robusta*—swamp mahogany—is now being planted throughout the Territory, because next to the blue gum it is one of the most rapid-growing of the genus and because in Hawaii it is an excellent windbreak. Some of the other eucalypts that have been used are the *E. citriodora,* which, however, is more valuable for ornamental purposes than for timber, and the *E. resinifera,* which is going to be a very good tree in dry places. Something like 30 different species have been planted so far. Of this number we are absolutely sure of five or six, and we are practically sure of about as many more. The rest need considerably more experimenting with before we can get to the point where we can definitely recommend them.

The purpose of the experimental plantation in Nuuanu Valley, and of others like it which we hope later to establish elsewhere in the Territory, is to procure just such information. Unless the Government does it, this work will not be done. But if the results are once secured and made public they will be of immediate use and value to many people.

DISCUSSION

In the discussion which followed, Mr. Zon raised the objection that unless there were very definite records available as to the physical and meteorological conditions in a given locality—more, for instance, by a good deal than were available for the upper mountain slopes in Hawaii—it was inadvisable to engage in forest planting, particularly by the seed-spot method. When somewhat exact data were available, then species could be selected and set out, with reasonable certainty of success, at less expense.

While theoretically this point of view is unquestionably correct, I can but believe that, now that the plots on the high mountains in Hawaii are established, useful results can be got from continuing the use of seed-spots and trying out additional species in this way. It may not be the best method, but under existing conditions it is one that can be worked. And so, while frankly admitting that it is not the scientific way of going about it, I contend that enough of benefit is likely to result to justify the effort expended.

REFORESTATION IN VERMONT

BY A. F. HAWES

Delivered before the Society January 9, 1913

Vermont is fortunate in being damaged less by forest fires than any other State of New England, about one-tenth of 1 per cent of the wooded area of the State having been burned over in the three and one-half years since the establishment of the Forester's office. The total estimated damage for this period is about $15,000, and the cost of extinguishing about $3,500. This comparative safety from fires makes it possible for the State Forest Service to devote more attention to forestry propaganda than in some States, and makes the policy of reforestation especially acceptable to the landowners.

The General Assembly of 1906 created the State Nursery under the direction of the University of Vermont, with an annual appropriation of $500, and small sales of stock were made in the spring of 1908. The Assembly of that year created the office of State Forester, with an appropriation of $8,000 for all purposes, and transferring the State Nursery to his direction. Since that time the nursery has been steadily enlarged, and the sales have each year increased. The State Forester has acted as broker for the people and purchased from outside nurseries large quantities of stock to supplement that raised by the State. In 1909 the blister-rust disease was unfortunately imported on white-pine stock. Since then pine stock has been purchased only from American nurseries, and $1,210 has been expended in eradicating the disease.

The sales made by the State Nursery have been as follows:

1909	195,000
1910	376,700
1911	480,300
1912	530,400
	1,582,400

Of these about 90 per cent have been white pine, the remaining 10 per cent being made up of Scotch and Norway pine, Norway spruce, black locust, and European larch. The chief reason that such a large proportion is of white pine is, I believe, the ease of raising this species, coupled with the general knowledge of its good qualities. The State Nursery has been unable to supply the demand for this species, and

has therefore not gone extensively into the raising of other species. Here is a good field for the private nursery company. In Vermont both the Scotch and Norway pine may be safely recommended for the lower elevation and drier soils. The European larch does well on the warm, well-drained slopes, and should be extensively planted. This, however, cannot be imported from a nursery to the South because of its early sprouting habit. There is a growing demand for Norway spruce, which has been extensively advocated on the strength of one small plantation. The International Paper Company, which is planting extensively, has in its nursery nearly 2,000,000 Norway spruce. While it is true that this species is more rapid growing than the red spruce, it is well known that it is short lived and that it is a poor reproducer. Plantations of the species which have come under my observation have done poorly compared to those of white pine on similar sites. These have all been on abandoned farm land, and the grass growth is apparently injurious to the Norway spruce. This, I believe, has been so in southern Germany. The white spruce is, in my opinion, a better tree to plant in Vermont than the Norway, but owing to the scarcity of its seed it has not as yet been raised in commercial quantities.

Two other species which should be widely planted on account of their rapid growth and value are the white ash and basswood. There is a special demand for the latter on the part of farmers interested in honey production, but at present neither ash nor basswood seedlings are available.

In deciding the prices to be charged by the State Nursery the aim has been to obtain, as nearly as possible, the actual cost. We have tried never to let the price fall below cost, so that the competition would interfere as little as possible with private nurseries. Three-year transplants of white pine have been sold for $5 per thousand, and two-year seedlings from $3.10 to $2.75 per thousand. In the spring of 1913 Scotch-pine transplants three years old will be sold for $5 per thousand, and Norway spruce of the same age for $5.50. We estimate that the cost of three-year white-pine transplants is made up about as follows:

Cost per 1,000 3-year White Pine Transplants.

Seed	$0.63	
Fertilizer and water	.12	
Labor first year	.60	
Use of screens	.30	
Supervision, and office expense	.32	
Cost of 1-year seedlings		$1.97
Labor and water second year		.27
Transplanting	$0.90	
Care third year	.90	
Land rental 3 years	.10	
Fertilizers	.25	
Water	.04	
Packing and boxes	.55	
		2.74
Cost of 3-year transplants		$4.98

The encouraging feature in Vermont is not so much the number of trees planted, but the general interest in the subject. The State Nursery has distributed stock to three hundred different landowners situated in every county of the State and in nearly one-half the towns. The average number planted by each landowner has therefore been about 5,000. These parties have been of all classes: farmers, lumbermen, business and professional men, city parks and water works, and corporations of various kinds. It must be remembered that other extensive plantings have been made by the International Paper Company. The plantations thus far made, being so widely scattered over the State, will in a few years be of great educational value in interesting others in forestry.

In fact, the educational value of the first plantations is already apparent because of the general success of the plantations made. An inspection made in 1912 of the plantations set out in 1909 showed that in twenty of these at least 90 per cent of the trees set were alive, and in ten others there were between 80 per cent and 90 per cent alive, while only three were reported as having less than half the trees living. In these cases the failure was due to a combination of poor planting and damage by cattle.

The present interest in forest planting in Vermont is due to a growing sense of security from fire and the educational program which has been pursued in connection with the State Nursery. It is not, in any way, due to the law which has for many years been on the statute books, providing a ten-year exemption from taxation on plantations. Of the

three hundred landowners who have planted, only three have taken advantage of this law. There is, at present, a bill before the General Assembly the passage of which, it is believed, will still further stimulate planting. This bill provides that lands planted with forests shall be assessed at not exceeding $3 an acre, and that no tax shall be levied on the growing timber until it is cut. At that time it shall be taxed 10 per cent of its gross stumpage value. It is further provided that it shall be optional with the owner whether he will place his land under this system of taxation, but if he elects to do so he agrees to manage the tract under the direction of the State Forester.

This bill was introduced at the request of the Forester and with the approval of the Governor, with the idea that it would win the approval of the legislature as a conservative measure, and once passed would serve as an entering wedge for reform in taxation of all forest property. Curiously enough, the chief opposition to it has been on the part of those who wished to go farther, and another bill has now been introduced using the same machinery as that provided in the Forester's bill. This provides that the owner of land covered with woody growth under eight inches in diameter, breast height, may place the same under the direction of the State Forester and be taxed as provided in the other bill. The aim of this bill is, of course, not only to encourage planting, but to discourage the cutting of immature timber. Lest such a law should result in handicapping a town for lack of revenue, the bill further provides that in any one year the amount of land put under this system shall not be great enough to reduce the grand list of the town 2 per cent. What the fate of these proposed bills will be cannot, at present, be predicted.

In this bill there is evidence of a growing interest in reforestation by natural as well as by artificial means. While planting will be more and more common in the future, the writer considers the chief purpose of the present planting as educational—a means of getting landowners interested in silvicultural practice. Planting is the handle by which the greatest number of people can be interested in forestry. As the nursery supplies grow—both public and private—it will be easy to induce an indefinite number to plant. Last year a circular letter was sent to about one thousand addresses, taken at random from the telephone directory, calling attention to the value of planting. A great many inquiries resulted, and several orders for stock from parties hitherto uninterested. Circularization of this sort by the State on an extended scale will be productive of great results, much greater than would result from circulars distributed by private nurseries.

The State forests must be spoken of in this connection, since, in Vermont, their purpose is mainly educational. The State owns at present (January, 1913) seven tracts, with an aggregate area of a little over 3,500 acres. These areas have been acquired either by purchase or gift, with the idea of furnishing demonstrations of practicable forestry work in as many sections of the State. They are located in accessible regions and have several types of forest, so that different lines of work may be demonstrated. For the most part they are culled lands, and comparatively little income can be realized from them for some time. If an annual appropriation of $10,000, now before the General Assembly, is granted, it will be possible to gradually acquire timber land where improved methods of lumbering can be demonstrated. In the meantime planting operations are being prosecuted on nearly all these forests, and these are already having the desired effect of interesting owners in the various regions in private planting.

In connection with these forests summer schools are held for the purpose of bringing together in the forest a number of people to consider forestry problems. While these are, as yet, new, it is believed that they will prove, when more generally known, a most effective way of stimulating activity among the smaller landowners.

Each year the requests increase for advice in the field, and while interest in natural reproduction is, as yet, very slight compared to that in planting, it is certainly gaining ground. The sentiment throughout the State is most favorable to forestry; and while comparatively few are, as yet, practicing it, there is no longer any open opposition, and nearly every one believes in it as a most important measure for the State. It may be said to rank in the interests of the people with the movements for good roads and agricultural schools. I am glad to say that we now have a Governor who has been interested in forestry from the first, and who has done more for its advancement than any other man in the State.

CERTAIN LIMITATIONS OF FOREST MANAGEMENT

A. B. RECKNAGEL

Contributed

This paper is far from attempting to cover completely so large a subject, but rather to bring up for discussion certain phases of forest management in the hope that members of the Society may contribute freely their views and experiences.

Considering the relation of fire protection to forest management, is there not a tendency, especially among graduates of eastern birth and training, to assume that forest management, *ipso facto,* demands complete protection from fire? Most plans of management contain the demand for complete fire protection; and yet this very demand may not always be well advised. Forest management has many limitations imposed upon it by silvicultural and economic conditions which may force a deviation from the axiomatic "complete protection."

Perhaps this point will be clearer if the interrelation between management and fire protection be analyzed and then several concrete instances given.

It is a safe premise to say that in putting any forested area under management one of the earliest considerations should be the establishing of an adequate protection from fire. To this end the following points should be considered:

A. The fire danger in the general region.

1. Cause, prevalence, and character of fires.
2. Sentiment of the community toward fires.
3. Prevalent methods of preventing and combating fires.

B. The specific conditions in respect to fires on the tract in question.

1. Past fires—their origin, extent, and damage done.
2. Present inflammability of the tract.
3. The menace or protection afforded by contiguous tracts.
4. The sum which can be profitably expended in fire protection.
5. The most feasible system of protection.
6. The character of protection desired—whether complete or partial, whether only during the progress of logging and regeneration or permanently.

A careful weighing of these points will often lead to the conclusion that permanent, complete fire protection is not warranted, either economically or silviculturally.

Fire protection, just as much as any other phase of forest management, must justify itself from the economic standpoint as far as the commercial (exploitation) forest is concerned. The protection forest and the forest for æsthetic purposes (game preserves, parks, etc.) are things apart, and secure indirect benefits which are difficult to gauge as a business proposition. But the test which can be applied to the commercial forest—be it National, State, communal or private—is what the Germans call "Rentabilität"—does it pay?

The returns from fire protection must offset the outlay, directly or indirectly. Therefore, the amount which should be spent for the protection of any given tract under regulated forest management depends in general on (1) the damage to the timber or grass or other forest product, (2) the situation—whether especially perilous, and (3) a reasonable interest on the capital represented by the tract.

Aside from certain silvicultural measures of burning (*e. g.*, burning over to secure regeneration of Douglas-fir cuttings, etc.), the question of the degree and permanency of fire protection from the standpoint of forest management is chiefly one of profit and loss. However, this question is far from simple of solution because of a great number of complicating factors. Who can, for example, correctly gauge the probability of fire running over a given tract in the next ten years? Who can figure on the probable soil depreciation and injury to growth which must be set off against the cost of protection? In other words, protection from fire secures a complexity of advantages, the economic desirability of which is well nigh impossible of determination in terms of dollars and cents. And yet, however roughly, one must make some calculations of probable profit and loss in order to fix in a businesslike way the amount which can be economically expended for the protection of a given tract.

A concrete example of a lumber company operating in the Southern pineries will serve to illustrate this: They desire to practice conservative lumbering, getting an annual yield of 20 million feet and cutting over the same area every 30 years. It costs them, say, $3,000 each year to protect from fire the area cut over that year, which yielded 20 million feet, and in 30 years will again yield 20 million feet. This means an initial investment of 15 cents per M for protection, which, discounted at 4 per cent to the end of the 30 years, means $2 per M of merchantable timber. Even allowing for the increasing value of stumpage and

lumber, $20 per M would be a very high figure for the profit at the time of the second cut, 30 years hence. This means that 10 per cent of the profit goes for protection—an extremely important item in calculating the business economy of conservative lumbering.

Much the same problem confronted the Forest Service in inaugurating the administration of the Florida National Forest. Based on Eastern (and Western) precedent, the writer did not hesitate in his working plan for the Western Division of that Forest to advocate—yes, to insist upon—complete fire protection. This was early in 1910. Three years of actual administration showed that not only would complete fire protection be prohibitively expensive; but that it would be unnecessary and dangerous. Controlled burning and the complete protection of areas undergoing regeneration has been successfully adopted instead.

A brief description of the Florida National Forest is essential to an understanding of the plan of managing the timber on it. The Western Division of this Forest, with an area of approximately 467,690 acres, is located in western Florida, between Pensacola and De Funiak Springs, in Walton and Santa Rosa counties. It comprises an almost level, sand plain, dissected by many small and some larger streams. The soil is chiefly an almost pure sand, of great depth, except in the occasional swamps.

The climate is subtropical, with a very short winter and no snow. The annual rainfall averages 56 to 60 inches; there are two main dry periods—March, April, May, and October and November.

The Forest, except for the occasional swamps, spruce-pine and oak "scrub," consists of a practically pure stand of long-leaf pine, with more or less scrub oak undergrowth. On favorable sites the slash pine takes its place with the long-leaf, which it closely resembles. The stand is usually very open; the trees are short (averaging 65 feet in total height), with limby tops. Individual trees seldom exceed 20 inches in diameter outside the bark at 4½ feet above the ground.

The growth is slow; trees one hundred years old average only 10 inches in diameter outside the bark at 4½ feet above the ground. At one hundred and fifty years the average diameter is 12½ inches; at two hundred years, 14½; a diameter of 16 inches is not reached until the two hundred and sixtieth year.

The scrubby character of the stand and the exceedingly slow growth is due primarily to the sand on which this timber grows.

The private holdings are intimately interspersed, checker-board fashion, with the Government land. The private land has been or is being worked for turpentine. Much of the timber has been boxed; now

cups are being used almost exclusively. There are 26 typical turpentine farms with typical equipment within or adjacent to the boundaries of the Forest.

Since most of the privately owned forest has been worked over, there is a very strong demand for turpentining the round timber belonging to the Government. Turpentine, therefore, is the main object of management in this Forest. It has been customary to sell the turpentined timber to lumbermen.

Under the Government plan of managing the long-leaf pine for the production of turpentine, the use of a system of cupping is basic. Scarcely less so is the cupping to a diameter limit. In order to prolong the productivity of the tree and minimize the injury, the chipping must be shallow and light.

Fire lines, not less than three feet wide in the narrowest place, must be hoed or plowed around the area covered by the turpentine permit in such a manner as to completely isolate it from adjoining lands. Natural fire-breaks, such as creeks, swamps, roads, etc., may be utilized. These fire lines must be made and receive the approval of the forest officer in charge.

Absolute fire protection on the Florida Forest proved impossible; the inhabitants were accustomed to burning over the area every year—to keep the brush down, in case of the turpentine operators; to improve the range, in case of the cattle and sheep men. Whether this practice is good or bad is beside the point; it is prevalent and serves the intended purpose of keeping the woods open. To keep out fire absolutely over the whole Forest is not only impossible without an extravagant expenditure, but would also serve no useful purpose. The woods would become "rough" with brush until they were a perfect fire trap; a fire occurring after several years of absolute protection would mean a holocaust, destroying large trees which are now immune; for even a sapling long-leaf pine can resist the light ground fires of areas burned over annually. Hence no advantage, and instead a positive danger, lies in absolute protection of the mature timber. However, areas undergoing regeneration must be protected from fire, and here, in the plan of management for the Florida Forest, fire protection centers. The turpentined areas are grouped, and to each group is accorded, when the cupped timber has been completely worked and logged, absolute protection from fire until reproduction has not only been achieved, but is at the sapling stage (over 5 feet high), when by gradual, light burnings the inflammable brush will be reduced and thus the area "opened up"

again. Save for these restricted areas, the rest of the Forest is practically immune from fire, for the cupped trees are raked as described above.

Such concentrated fire protection is probably the best economic and silvicultural solution of the problem in the Southern pine belt; certainly in the long-leaf pineries. Similar conditions where partial protection is the best solution will doubtless occur to the reader—tracts where the mature timber is in no danger of fire and where protection can be centered on the areas of young growth.

IMPROVING COMMERCIAL METHODS OF KILN-DRYING LUMBER

BY HARRY D. TIEMANN

Contributed

Necessity of Drying Wood.

Before wood can be used in the arts or manufactures, it is generally necessary to remove the greater part of the water which it contains. In its natural state wood contains from 30 to over 100 per cent of its dry weight in the form of moisture; dry wood therefore is in an unnatural state, since from the time it is first formed until the tree dies or is cut down the wood has never once become dry.

If it were not for the shrinkage which accompanies the reduction in moisture, the drying of lumber would be a simple proposition. This shrinkage is also the chief reason why it is desirable to have wood at the proper moisture in which it is to remain before it is manufactured into finished articles. The swelling of dry wood when it reabsorbs moisture in moist air is a like difficulty in its utilization.

Partially dried wood will swell again to approximately its original size, but thoroughly dried wood will not swell quite as much under the same conditions. In fact, wood dried at high temperatures loses some of its hygroscopicity. This is another reason why it is necessary to thoroughly dry wood before it is manufactured.

The Problem of Drying.

If drying wood were simply a matter of evaporating moisture, there would be very little problem to it, since it would be a simple mechanical problem of supplying the necessary heat.

On account of shrinkage the necessity of transmission of moisture through the wood substance, and the effect produced by heat and humidity upon the substance of the wood causing physical and chemical changes, and of still other factors in some cases, the drying of wood is far from a simple matter and becomes a very difficult problem, especially with certain species.

The earliest builders of kilns took into consideration only this first part of the problem, that of evaporating moisture. A draught of dry air, usually from some form of furnace, was used. There are in existence a number of patents for apparatus of this or similar kinds. With

some species of wood, such as soft pines, Douglas fir, and spruce, the operation of drying involves but little more than this, but with most species, especially with the hardwoods, the consideration of the physical effect of the operation upon the wood is the controlling factor, and the problem becomes very complex and difficult. In fact, almost every species behaves differently and requires different treatment.

Objects to be Obtained in Commercial Operations.

Commercially there are three main objects to be fulfilled in the kiln-drying of lumber, namely: (1) to reduce its weight for shipping; (2) to reduce the quantity necessary to carry in stock when allowed to air-season by hastening the rate of drying, and (3) to prepare the wood for whatever use it is to be applied; that is, to improve the quality of the product.

Drying Softwoods Primarily to Reduce the Weight.

As to improvement of present methods for the first purpose alone there is little to be said. It is usually only the easily dried species which fall under this heading, and the quickest and most economical way of evaporating moisture is as a rule the method called for. Of course, it must not be one which will injure the wood to any extent. Ordinary air-drying will accomplish the purpose, but may not prove the most economical on account of the large amount of lumber which must be carried in stock in the yards.

In order to hasten the rate of drying application of heat is necessary, and to convey this heat throughout a pile of lumber requires a good circulation of air. The heat is supplied either by a furnace or more often by steam-pipes in the kiln itself, and the circulation is accomplished by a forced draught from a rotating fan, by ventilation, or by gravity currents within the kiln.

The efficiency of the operation as well as the rate of drying increases with increase in temperature. Consequently it is economical to run the temperature as high as the wood will stand. Temperatures above the boiling point of water are frequently used in drying softwoods for this purpose, but the process cannot be applied to most hardwoods, as they will check and shrink too greatly, besides being injured in their toughness.

In the kilns operating at such high temperatures the practice is generally to subject the lumber first to free steam for an hour or longer, and sometimes the steam is allowed to escape into the air during the entire process of drying. This is done in order to supply sufficient

humidity to the air, as even the easiest woods to dry are apt to check and case-harden at such high temperatures if the air is too dry.

When the temperature exceeds 212° Fahrenheit *superheated steam* at atmospheric pressure may be utilized in place of air. In fact, a high humidity at atmospheric pressure and at a temperature above 212° can be produced only by superheated steam, since the pressure of water vapor at 100 per cent relative humidity and 212° F. temperature is equal to that of the atmosphere, and consequently the water vapor will entirely displace the air under these conditions. At temperatures above 212° and atmospheric pressure the humidity must be less than saturation or 100 per cent (the divisor in the term for relative humidity necessarily remains the pressure of one atmosphere, which is the pressure used in the operation, the dividend being the pressure of saturate vapor corresponding to the temperature used).

The rapidity with which softwoods are dried at these high temperatures is truly remarkable. One-inch Douglas fir is now being dried in many cases in from 40 to 65 hours at average temperatures ranging from 183° to 213° F. In one instance known it is being dried in the remarkably short time of 24 hours. This is by use of superheated steam entering the kiln under forced draught at 300° F. In this case the chamber is first filled with saturate steam for two hours, after which the temperature is raised to 300°. The condition of the product, however, was found to be far from uniform, the moisture varying from 2 per cent on the outside to as much as 18 per cent in the middle of the pile.

The Douglas fir used in the various processes referred to above contained from 27 to 34 per cent moisture when it was put into the kilns, and was reduced, except in the special case cited, to from 4 to 10 per cent.

This result is secured with practically little or no loss from checking, warping, or discoloring. There is little question, however, but that the wood is rendered brittle by this excessive treatment.

Material over an inch thick will take proportionately longer to dry, and when 3 or 4 inches thick there is danger of checking even with the easiest woods to handle.

Except in the case of the 24-hour treatment, the operations mentioned were conducted in tightly closed kilns of the progressive type, where the only circulation is that produced internally by gravity currents.

The drying of most species of softwoods requires a considerably longer time, due in part to the greater amount of water which they contain

while green. Some species, as bull pine and redwood, are discolored or injured by too high a temperature while moist. Others, as tamarack and cypress, warp and case-harden, so that not all softwoods are amenable to this treatment.

The problem of reducing shipping weights is of special importance with the western softwoods, and it is in the Northwest where these rapid-drying methods are being used to the greatest extent. In the East spruce is shipped by water directly from the mills in the green condition, and even long-leaf pine is shipped from the South without seasoning.

As most of the western softwoods are susceptible of this forced treatment without serious detriment, the problem of drying wood for the purpose of reducing its shipping weight may be said to have reached a satisfactory condition, and there is little call for further improvement here.

Of course, in dryng for reduction in weight, other things are accomplished incidentally, as reduction in tied-up capital, reduction in hygroscopicity and the fixing of resin.

Drying for the Purpose of Carrying Less Stock.

The second problem, that of hurrying the process of drying in order to reduce the quantity of lumber necessary to carry in stock when allowed to simply air-dry, is analogous to the first one, and is of course accomplished in any case where the wood is dried in a kiln. It is sometimes applied to hardwoods, but generally is subordinate to the third problem discussed below, or at any rate it depends upon the possibility of solving either the first or third problems. It will be unnecessary therefore to discuss it separately.

Drying Wood to Improve its Condition.

The third problem applies to most of the hardwoods and some of the softwoods also. It is at present for the most part very far from a satisfactory solution, and is likely to remain so in many cases for a long time to come on account of its complexity. The problem has never yet been placed on a scientific basis for the reason that so little is known of the nature of wood and what takes place internally as the wood dries. The operations moreover have never been placed upon even a uniform commercial basis. Methods in use are often haphazard and vary from one extreme to the other. One-inch hardwoods, such as oak, maple, elm, hickory, are being dried under various conditions at temperatures ranging from 65° to 165° F. and humidities at the beginning of the opera-

tions varying from 100 per cent to as low as 45 per cent and doubtless in many unmeasured cases even lower. Hardwood stock is usually first air-dried from three to six months and sometimes three years before being placed in the kiln. The time of drying in the kiln varies from four days to three weeks for 1-inch boards, and for 3-inch stock from two to even five months. In some cases preliminary steaming is used by allowing free steam to flow into the air for 24 to 36 hours at temperatures of 100° to 160° F.

Recently the operation of steaming the lumber from 15 to 30 minutes at a pressure of 15 or 20 pounds is coming into favor for certain species of hardwoods. More rapid and uniform drying is claimed to follow such treatment whether dried in the air or in the kiln.

Thus it is clear that there is no standard method in use for drying hardwoods. It is true that in some cases satisfactory results are being secured, but in the majority there is at least some improvement to be desired.

The trouble may lie in any one or in all of the following circumstances: Too long a time required; unequal drying in different parts of the pile; non-uniform drying in portions of the same stick—for instance, the outside becomes dry while the inside remains moist; case-hardening and honeycombing; warping and checking; discoloration; mildewing and sap-staining; injuring the mechanical properties by cooking, making it brittle or brash; excessive and unequal shrinkage.

There are several species of wood which have not as yet been dried with complete satisfaction in any kiln. Among these are red and black gum, cypress, swamp-grown oaks, and very thick stock of all heavy woods.

Losses through Poor Drying.

The loss through degrading and injury done in drying varies considerably. Some of the best manufacturers claim no loss on certain species; others 1 to 3 per cent, and in difficult wood, as gum, from 7 to 10 per cent.

Very often bad results are due to ignorance of the fundamental principles in drying wood and to placing a man with little or no technical training in charge of the dry kiln. Frequently the engineer who runs the boilers and engines for the factory has charge of the kiln; sometimes the yard foreman. In such cases the results as a rule have been found to be poor. Occasionally a skilled man with technical knowledge has charge, and good results generally follow.

Necessity of Hastening the Process of "Natural" Air-drying.

Altogether too little attention has generally been given to the part of the business dealing with the conversion of the green wood into the usable dried material. Where it was formerly practicable to carry enough lumber in stock to allow it to air-season slowly for from three to five years, but little technical attention needed to be paid to the drying process. It just took place "naturally," as is frequently said, and if carefully piled and the ends painted it was ultimately in excellent shape for working—what portion of it escaped rotting. In some cases the losses due to rotting of lumber piled to air-dry out in the yard is very great. For the finest kind of material, such as the best grade of car stock and for ship-building and for high-grade cabinet-work, air-dried wood is still preferred to that in which the process has been hurried by heat.

When the call for lumber is so great that to carry a full line of stock for three or five years means a large financial loss in investment, it is well worth while to give the subject of "forced" drying the technical consideration which it deserves as much, and even more than, any other part of the business. This fact becomes evident when one considers that the quality of finished product depends as much upon the process to which the wood has been subjected in drying as it does upon the material itself. Defects produced in the drying process can never subsequently be wholly rectified. A good drying plant is an asset; a poor one a liability.

Desirability of Kiln-drying to Improve the Quality of the Product over Air-drying.

Even where a large stock can be conveniently carried, it is desirable for some purposes to kiln-dry the lumber. Thorough kiln-drying reduces its hygroscopicity, hardens resinous materials and gums, thus preventing them from exuding and causing trouble in the finished product. In some species, as swamp-grown oak, air-drying will cause serious checking, and in others, as loblolly pine, sap gum, etc., rot or stain is very apt to occur if the lumber is piled to air-dry in a warm climate.

Reduction in Hygroscopicity and Swelling.

In order to show what reduction in hygroscopicity and consequently in subsequent swelling and warping results from kiln-drying as compared to air-drying, the following table is given. The figures are taken from a series of tests carried on five or six years ago for the purpose of determining the effect of various processes of drying upon the strength

of the wood. The test specimens were of two kinds: (1) small ones, 2 x 2 x 6 inches, for the compression tests, and (2) large ones, 2 x 1½ x 30 inches, for bending tests. Discs were cut across the blocks at the point of failure and the moisture content determined. Each figure given in the table is the average of seven specimens. Three sets are given for each treatment. The first column gives the species, the letter designating the treatment and the final average temperature at the end of the drying process. The sets of seven pieces numbered 3 were simply air-dried and used as a check to which to compare the other two sets. Sets numbered 4 were first air-dried about a year, then kiln-dried as indicated, and finally placed aside with the check specimens to air for a year or more longer. Sets numbered 5 were soaked from the green condition the same length of time that sets 4 were air-dried, respectively, and then kiln-dried together with sets 3 and placed aside to air with the others. The airing took place in the open under a shed on the north side of a building, where they were protected from sun and storm. The comparative tests were all made at the same time. Thus it is seen that the results shown are reliable and not accidental in any respect. The comparative specimens, Nos. 3, 4, 5, were *matched* in each of the seven series, of which the figures shown are the averages.

TABLE 1.—*Effect of Kiln-drying upon the Subsequent Moisture Condition as Compared with Simple Air-drying.*

(Figures are moisture per cents of the dry weights)

Species	I. 2 x 2 x 6 inches			II. 2 x 1½ x 30 inches		
Treatment number and maximum temperature degrees F.	Check	Kiln-dried		Check	Kiln-dried	
	Air-dried, No. 3	Previously air-dried, No. 4	Previously soaked, No. 5	Air-dried, No. 3	Previously air-dried, No. 4	Previously soaked, No. 5
White Ash						
A. 145°	14.9	13.8	13.7	15.0	13.0	13.4
Red Oak						
A. 145°	12.4	7.6	9.6	12.9	10.4	10.2
B. 170°	12.4	10.6	10.6	13.3	9.5	9.8
C. 212°	12.0	9.4	9.5	14.2	11.0	11 1
D. 274°	12.6	8.9	9.9	....	....	....
Loblolly Pine						
A. 145°	12.7	11.9	11.8	13.4	12.3	12.2
B. 170°	14.3	12.2	12.5	....	....	....
C. 208°	13.5	12.2	12.0	15.4	13.9	13.9
D. 270°	13.9	10.9	12.1	....	....	....

This reduction in hygroscopicity appears to be a permanent change brought about by some chemical change in the wood substance.

Improvement Possible in Drying Hardwoods.

Improvement in present methods of drying must follow chiefly three paths: in reducing the time of drying; in reducing losses due to injury, as checking, warping, staining, and unequal shrinkage; and in improving the quality of the output.

Before taking up these improvements in detail I will give a brief classification of present methods and of the kinds of kilns in use with these methods.

Classification of Present Methods of Drying and Types of Kilns.

In all cases the kilns may be either of the progressive kind or of the compartment kind, and preliminary steaming may or may not be used. In the progressive kind the lumber is shoved through a long chamber, while the conditions in the chamber remain constant, usually moist at one end and dry at the other. In the compartment kind the lumber remains stationary, while the conditions are changed as the lumber dries.

1. Dry Air. Simply a hot box or forced draught of dry air. In use with other materials, but now obsolete with wood.

2. Moist Air. Attempt is made with more or less success to retain a large amount of humidity at the beginning of the drying operation.

a. Ventilating Kilns, or "Natural-draught Kilns," as they are sometimes called. In these a portion of the moisture evaporated from the lumber is returned to the entering air by a suitable arrangement of ventilators and part is allowed to escape to the outer air.

b. Forced-draught or Blower Kilns. The moisture-laden air is in part recirculated by means of a blower and part allowed to escape, the proportion of each being regulated by dampers. The blower may act either as suction or as compression, drawing air out or forcing it into the kiln.

c. Condensing Kilns. These kilns, if well constructed, are independent of outside atmospheric conditions, the superfluous moisture being removed by some kind of condenser, either in a compartment within the kiln itself or in a separate chamber, and the same air is recirculated. The circulation may be produced either by gravity currents in the kiln or by means of a blower.

The condensing kiln is the most modern type in commercial use for drying hardwood lumber.

d. Humidity-regulated Kiln. This is similar in principle to the condensing kiln except that the humidity is positively controlled at all stages of the operation. So far as known the only kiln of this kind is the one invented by the writer, with which the Forest Service has been experimenting for the past two years. In the kiln referred to increased circulation of the air is induced by the force of the sprays of water used in the humidity-regulating chambers. Theoretically correct drying conditions can be obtained with this kiln (figure 1).

e. Oven Kiln. This is a new type of moist-air kiln recently coming into favor in the Pacific Northwest for drying softwoods. Essentially it consists of a chamber nearly air tight in which the lumber is heated until the moisture is vaporized. It requires a temperature above the boiling point in order to vaporize the moisture at atmospheric pressure. When properly working it really becomes a superheated steam kiln, since the air must be expelled by the water vapor. As conditions would be saturate at 212° F., evaporation is produced by the superheat above this temperature, or by direct radiation from the heaters. If ventilation is allowed, these conditions are destroyed, and a very imperfect form of moist-air kiln is the result.

A temperature as high as 255° F. has been used with success on Douglas fir. These kilns are not suitable for hardwoods on account of the high temperature required.

3. SUPERHEATED STEAM. The air is completely displaced by steam (vapor) at atmospheric pressure, and evaporation is effected by superheating the steam, or superficially by radiation from the heaters. One peculiarity of this process is that no matter what the degree of superheating used, the lumber *while wet* must remain at 212° or very slightly above this temperature. As the wood dries, however, its temperature will rise, due to the hygroscopicity of the wood substance or its moisture-retentive force, until its temperature may reach very nearly that of the superheated steam. This is where the danger lies, as the superheated steam may then act as proportionally low relative humidity in the air and cause too rapid surface drying. Thus, at 300° F. the absolute pressure of saturate vapor is 67.1 pounds per square inch, but the actual pressure of vapor present is only 14.7 pounds (working at atmospheric pressure). Therefore, the relative humidity is $14.7 \div 67.1 = 21.9$ per cent, an extremely low amount.

The only medium of conducting heat to the wood effective for evaporating moisture (other than by direct radiation from the heaters) is the water vapor, and it is evident that this can convey only as much heat to produce evaporation as it contains above 212°, since it becomes

saturate at that temperature and no more evaporation is possible. While there is less danger of checking or case-hardening the wood on this account than were air present also at the same temperature, the heating capacity is less, and an enormous volume or an excessive degree of superheating is required.

It is evident, moreover, that the amount of evaporation in the case of superheated steam must be proportional at a given temperature to the *rate* of circulation, always a bad feature in drying operations, as it causes uneven drying.

The high temperatures required limit the application of superheated steam to certain kinds of softwoods. Vacuum methods have been tried to reduce the temperature, but the trouble is the heating medium is thereby also reduced and the operation is in general impracticable on a large scale on account of mechanical difficulties.

4. PRELIMINARY STEAMING IN SATURATE STEAM. This is not, strictly speaking, a method of drying in itself, but may form part of almost any drying operation. It has come into considerable prominence of late. It consists simply in treating the lumber in saturate steam from atmospheric pressure up to 30 or 35 pounds gauge for varying lengths of time preliminary to drying. The length of time in practice varies from ten minutes to several hours, according to the pressure used and the purpose. This differs from the common practice of allowing free steam to escape into the air at temperatures less than 212°, usually at 100° to 180° F., and for 24 to 36 hours, which merely accomplishes the holding of the air at 100 per cent humidity during this time. The saturate-steam or pressure-steam process may be used together with any of the drying methods outlined above, or it may be followed by simple air-drying. Extravagant claims are made for this simple treatment. It appears to be beneficial with certain species, as red gum, etc., in hastening the drying, reducing the hygroscopicity, fixing the gums and resins, and in darkening the color. It is not applicable to all woods nor for all purposes, however. Some kinds, as oak, will open up numerous fine checks as soon as removed from the steam, and, where the strength of the wood is important, steaming is detrimental to some species at least, as it makes the wood more brittle.

A full discussion of all these methods and types of kilns would be too extensive to include in this article, but the outline just given will suffice for further discussion of possible improvements. Naturally each manufacturer claims his kiln to be the best, and to be theoretically correct in principle. Many go so far as to guarantee specified results from their kilns. In many instances these results are not being obtained,

yet it is probable that it is very difficult to hold a manufacturer to such a guarantee on account of all the variable conditions to be met with.

Absurd Statements Published in Dry-kiln Catalogues.

In many cases—in fact, in most of the cases—the advantages claimed by the promulgators are based upon erroneous conceptions or upon superficial details, the fundamental principles being overlooked. What success has in a measure been obtained has usually been by a long series of empirical trials or by accident.

To give an idea of the absurdity of some of the claims made by dry-kiln promulgators, look at these quotations copied from their recent catalogues:

[Elements composing the waste material in a tree] "are found in greater proportion as you approach the center of the tree, where they are solidified by the constricting force of each succeeding year's growth. . . . For this reason the heart edge of a true quarter-sawed board will shrink more . . . than the sap edge."

"The wood fiber or skeleton of a board is not materially affected by moisture, but if the spaces between the fibers are filled with solidified sap the same piece of lumber will be extremely sensitive to moisture."

"The natural lines of the fiber will be distorted by the pressure of the sap globules in swelling, while in shrinking they will also be drawn in various directions owing to the unequal distribution of sap masses throughout the wood. This is the true cause of crooked lumber."

"A combination of steaming, direct radiation, and elimination, whereby we explode the sap cells [!], dissolve the pigment, acids, and organic matter, and extract them from the pores of the lumber, leaving only the solid wood fiber, which is subject to neither shrinkage or swelling to an appreciable extent, which gives to the lumber we dry that characteristic most to be desired—permanency of dimensions."

"It is a law of nature that cold air will rush to hot."

"The proper amount of humidity must be carried in the drying chamber . . . to explode the sap cells . . ."

Apparatus and Construction up to the Standard.

Improvements in apparatus and construction have been carried out on a much better basis, as they have been worked out by engineers upon well-known principles. Heating systems, trucks, doors, and steaming chambers can all be obtained of an excellent character.

The Fundamental Principles of Drying Wood.

Some of the fundamental principles (we do not know them all as yet) of most consequence in drying refractory lumber are these:

(1) Since drying must take place from the surface, this should not be allowed to progress any more rapidly than the moisture is transferred from the center outwardly; otherwise case-hardening or surface-checking must occur.

(2) Moisture in wood tends to transfuse away from the hot towards the colder portions. Consequently it is important that the wood be uniformly heated through to the center before any surface drying takes place. The rate of transfusion increases as the temperature is raised; consequently the temperature should be as high as will comport with the physical requirements of the wood for efficient drying.

(3) Wood becomes soft and plastic while hot and moist, some species, such as oak, redwood, and eucalyptus, becoming much more so than others, as poplar and pine. In this condition their tenacity is greatly reduced, so that the fibers are easily pulled apart and the cells themselves often collapse and separate under the strains brought about by shrinkage. Consequently the maximum feasible temperature to which the operation can be pushed must be governed by the species and the condition of the wood.

(4) The shrinkage of hardwoods is greater the higher the temperature at which drying takes place while they are still moist. In some species, notably eucalyptus and redwood, the thin-walled, and even the thick-walled, cells (fibers) collapse like hollow tubes under lateral pressure when drying takes place at too high a temperature. This is a very significant fact and one not well known. When the wood becomes fairly dry and the fibers become stiff or "set," much higher temperatures may be used without producing this injurious effect. Hence the advantages of air-drying certain hardwoods before they are placed in the kiln. This is also the reason why air-drying is sometimes considered better than kiln-drying.

This and the preceding paragraph give the reasons for the possible harmful results of preliminary steaming.

(5) The drying should take place uniformly over the entire piece; otherwise unequal internal stresses are produced which cause the stick to warp and shrink unequally, as it yields to these stresses while moist and plastic.

(6) Thorough drying reduces but does not eliminate the hygroscopicity and consequently the subsequent swelling and shrinking or "working," as it is termed.

(7) Too much or too severe drying produces brittleness, so that when the wood reabsorbs moisture from the air it is not so strong and tough as air-dried material or that which has been more gently dried.

(8) Wood will absorb or lose moisture in the air according to whether the proportion of its moisture-content to its fiber-saturation point is less or greater than the relative humidity of the surrounding air.

It is not necessary to give here the principles governing the evaporation of moisture. One fact, however, may be pointed out which is likely to escape notice: that the lumber, so long as its surface is moist, cannot reach the temperature of the surrounding air except when the air is saturated. Its temperature in fact corresponds to that of the wet bulb of a wet-and-dry-bulb hygrometer.

In order to conduct the drying operation in accordance with these physical principles the following factors need to be taken care of:

(*a*) The lumber should be heated clear through before drying begins. This can be accomplished by preliminary steaming or by heating first in a high relative humidity, sufficiently high to prevent evaporation.

(*b*) The air should be kept humid at the beginning and reduced, as the wood dries, at such a rate that the transfusion of the moisture through the wood itself keeps pace with the rate of drying at the surface, so the wood does not case-harden nor check. If checking begins it indicates too low a humidity and that drying is proceeding too rapidly.

(*c*) The temperature of the lumber should be maintained uniform at all points and be as high as the particular species of wood will endure without causing the injurious effects already explained. For this purpose a very large circulation of air is desirable, even more than would be necessary for simply evaporating the moisture.

(*d*) Control of the rate of evaporation must be effected by regulating the relative humidity in the air and *not* by reducing the circulation. Where the humidity is low and the rate of drying is held in check by reducing the draught, non-uniform drying is inevitable. The rate of evaporation in this case is governed by the amount of heat given to the wood by the moving air, and wherever this varies in amount the rate of drying will vary. Throughout a load of wood it is practically impossible to maintain an equal velocity of air in contact with every portion of the lumber. Consequently, when the humidity is too low and circulation is unequal, poor drying is inevitable.

On the other hand, if the circulation is sufficient at all points to impart to the wood all the heat required for evaporation, thus maintaining its temperature uniform, and if the rate of evaporation is con-

trolled by the *relative humidity in the air,* then the rate of drying is independent of the circulation so long as it exceeds the minimum amount requisite, and uniform drying results. If the humidity is of the proper amount, excessive circulation does no harm to the wood, as it will not increase the rate of drying, but it may use up an unnecessary amount of heat and energy and thus cut down the mechanical efficiency of the kiln. Excessive circulation is, therefore, to be avoided, but it is better to have too much than too little.

Ideal drying, therefore, is dependent upon (1) ample circulation and (2) control of humidity at the proper temperature for the species in question. These are the most important factors in the drying of wood.

(*e*) The degree of dryness attained, when strength is of prime importance, should not exceed that at which the wood is likely to remain in use, but when shrinkage and swelling are of first consideration it should be carried to as great a degree as possible and subsequently be brought back to the condition under which the wood is to be used by exposure to the air before the lumber is manufactured.

No Kiln on the Market Fulfills All These Conditions.

Practically perfect drying is possible in a kiln in which these conditions can be fulfilled. In some cases, however, it might not be practicable for financial reasons to attempt to carry out such a system. No kiln on the market, so far as known, fulfills all these conditions.

Probably the nearest approach to this ideal kiln, of any on the market, is the condenser type, in which a pipe condenser is placed in a narrow flue on the side of the drying chamber and the air is recirculated by natural draught brought about by alternate heating and cooling. This type still lacks the principle of direct humidity control, and the circulation is dependent upon gravity effect alone.

It seems strange that heretofore the principle of direct humidity control has not been applied to the dry kiln for lumber.

A Humidity-regulated Dry Kiln.

It is in this feature primarily that the kiln designed by the writer* differs from the condenser kilns now on the market. In place of the pipe condenser is used a series of sprays of water, the *temperature* of the water being regulated to produce any desired humidity.† The same air

* U. S. Patents 1,019,743, March 5, 1912, and 1,019,999, March 12, 1912.

† In order to secure freedom from numerous patented humidity-controlling devices a new system was worked out and patents secured therefor, No. 963,832, July 12, 1910, and No. 981,818, January 17, 1911.

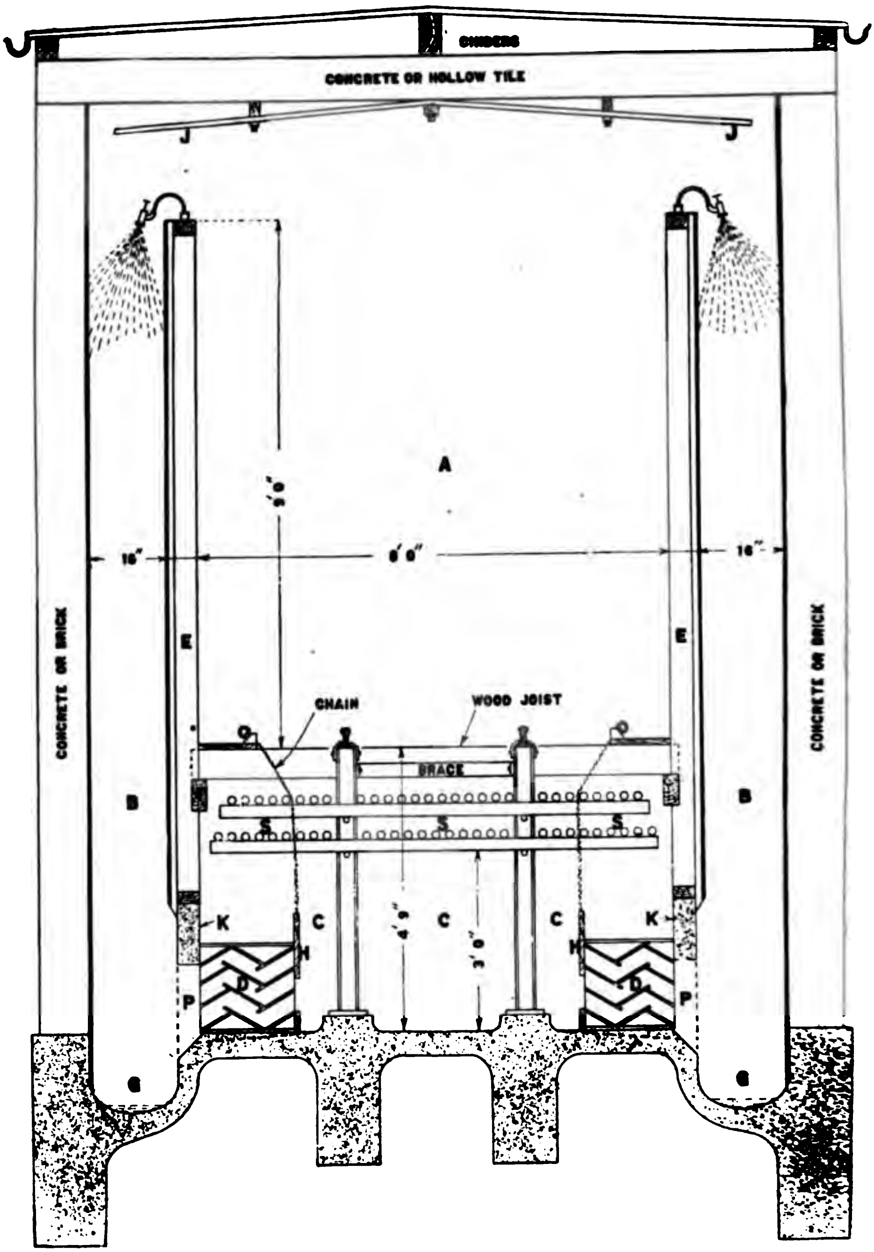


FIGURE 1.—*Section Through Tiemann Humidity-controlled Dry Kiln*

is recirculated, the spray being separated therefrom by suitable baffle plates. The force of the spray, moreover, helps to increase the gravity circulation.

Description of the Tiemann Humidity-controlled Dry Kiln.

Figure 1 is a representative cross-section of this kiln. The air leaving the bottom of the side spray chambers is in a saturated condition. It then passes under and up through the heating coils, where its temperature is raised to whatever degree is required in the heating chamber. Now, the temperature of the saturated air as it leaves the bottom of the spray chambers is the *dew-point* of the air after it has been subsequently heated by the steam coils. Thus by changing the temperature of the dew-point any desired humidity may be obtained in the drying chamber. This is accomplished by simply regulating the temperature of the spray water.

The temperature of the drying chamber is controlled by a thermostat acting on the steam main. For a wider range of temperatures a reducing valve is placed on the steam supply, high-pressure steam being used and reduced to any pressure required. The temperature of the spray water is automatically controlled, and most of it is recirculated by a pump.

Theoretically the efficiency of this kiln is much greater than that of a ventilating kiln working under the same conditions of humidity and temperature. Practically, however, it is hardly possible to reach the conditions for the best theoretical efficiency, as there is apt to be an excess circulation of air which reduces the efficiency correspondingly. The practical working efficiency has not yet been determined experimentally. A noteworthy feature is that *all* of the heat—both the latent heat of evaporation from the lumber and that required for heating the circulating air—is taken up by the spray water. In this way it all reappears in the temperature of the overflow except that which is lost through radiation through the ceiling, end doors, and floor. Not much is lost through the side walls on account of the spray chambers. This kiln is practically independent of outside atmospheric conditions. The last remark is true also of other types of condensing kilns.

Experiments with this kiln have been carried out for the past two winters at Berkeley, Cal., in drying eucalyptus wood. The practicability of the operation has been substantiated in these experiments and the principles discussed have been established. Further improvements, however, are being made in the mechanical construction and means for operating. The humidity control was found to check up satisfactorily

with that actually obtained, and the circulation was found to be about 200 cubic feet per minute for every foot length of the kiln, at a temperature of about 150° F.

A small kiln of this kind is now in operation at the Forest Products Laboratory at Madison, Wis.

There are three disadvantages in the practical use of this kiln as compared with a common ventilating kiln with natural draught. These are the somewhat more complicated construction, the general difficulty of taking care of the spray of water in the side chambers, and the greater skill needed in properly regulating the humidities.*

In deciding upon installing such a kiln the question to be decided is whether the advantages gained in better quality of product or quicker drying are worth the extra expense. Over the pipe-condenser type there is one mechanical advantage in that there is not the series of condenser pipes to rust out.

It is probable that further simplifications in the construction and operation will be made, so that these objections will be largely overcome. Greater care in operation, however, must go hand in hand with improvement of the product. But little care is required to push lumber through a progressive hot box and take it out at the other end, and if the result justifies the means there is little left to be desired. But where better drying is called for, as in other things, more care and skill must be given to the operation.

Principles Governing the Selection of a Kiln.

The many points to be considered in deciding upon a dry kiln may be summarized in the following classification:

1. *The Purpose of Drying:*

a. For reduction in weight only, with easily dried species.

b. For decreasing the amount of stock necessary to be held in the yard.

c. For improving the quality of the product.

d. In order to utilize some refractory wood which cannot be satisfactorily air-dried.

e. To prevent stain, rot, and to "kill" volatile materials, as gums and resins.

f. To prepare the wood for some special use, as for subsequent bending.

[* Also higher cost of installation.—ED.]

2. *Species to be Dried:*

a. Easily dried conifers, requiring no special care.

b. Woods which dry readily, but require care.

c. Refractory woods which require extreme care, as white oak, for example.

d. Woods which ordinarily cannot be satisfactorily air-dried, such as red gum.

3. *Permamency of Plant, and its Relationship to Other Factories and Buildings.*

In some cases the cheapest kind of a kiln, consisting of little more than a wooden room with steam pipes on the floor, would be the most economical; in others a simple room, either of wood or brick, with some means of retaining part of the humidity either by closing up tight or by recirculation; and in still others, where the species to be dried will stand high temperatures, a substantially built room fitted for carrying temperatures above the boiling point, or for forced draught and superheated steam, would be called for. In many cases, however, not any of the foregoing classes would answer the purpose, and in such cases more complicated systems of operation are necessary. It may often happen that the initial outlay is altogether an insignificant consideration provided satisfactory results can be obtained, and this is where the humidity-regulated kiln is of greatest application. Such cases may arise from either of two causes: first, from the superior quality of the product desired, as wagon and car stock, fine furniture and interior finishing, musical instruments, etc.; second, where the woods are exceedingly difficult to dry, even by long air-seasoning due to warping and checking, and are of little value unless well dried. The value of the wood depends largely upon the drying operation. As examples of such woods may be mentioned red gum, swamp-grown oak, cypress, eucalyptus, etc.

By proper drying it is probable that many hitherto considered inferior species may be made to serve the purpose of kinds becoming scarce.

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Separates:

Better Methods of Fire Control, W. B. Greeley, 13 pp. (out of print).

Bibliography of Southern Appalachians, Helen Stockbridge, 82 pp. 25 cents.

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PROGRAM OF MEETINGS, 1912-1913

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- (*b*) Vermont's reforestation policy. A. F. Hawes.
- (*c*) Results achieved in the operation of Massachusett's reforestation law. F. W. Rane.
- (*d*) The acquisition and use in Wisconsin of State forest reserves. E. M. Griffith.

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- (*d*) Forest types and quality classes.

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February 6. Open Meeting. Suggestions for a Plan of Taxing Growing Timber. Prof. F. R. Fairchild.

February 20. Annual Executive Meeting.

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How Can We Make Our Stumpage More Valuable? H. F. Weiss.

April 3. Open Meeting. The Nation and the States in Forestry. Gifford Pinchot and Henry S. Graves.

April 17. Special Executive Meeting.

May 1. Open Meeting. Progress in Forest Planting on the National Forests. W. B. Greeley.

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JANUARY, APRIL, JULY, AND OCTOBER

In Memoriam: Fred Gordon Plummer

The Society of American Foresters has lost one of its most active and valuable members through the death, on August 15, 1913, of Fred Gordon Plummer, geographer of the Forest Service. He was a constant attendant at the meetings of the Society and seldom failed to inject a new light into its discussions. His vein of humor was always in evidence and the points which he made were often clothed with a piquant or whimsical expression which greatly increased their effectiveness.

He made many valuable additions to forest literature and wrote the earliest descriptions of many of the National Forests of Washington, Oregon, Arizona, New Mexico, and California. A partial list of his published writings on forestry includes:

Chaparral; studies in the dwarf forests, or elfin-wood, of southern California: Forest Service Bulletin 85.

Forest Fires; their causes, extent and effects, with a summary of recorded destruction and loss: Forest Service Bulletin 117.

Forest Types; analysis and synthesis of the term from a geographic standpoint: Proceedings of Society of American Foresters, April, 1913.

The Growing of Eucalyptus: Proceedings of Society of American Foresters, 1910.

Lightning in Relation to Forest Fires: Forest Service Bulletin 111.

Report on Calaveras Groves of Big Trees, California: U. S. 60th Congress, 1st Session—House.

Mr. Plummer at the time of his death was working, in coöperation with Mr. Graves, on a statistical circular which would cover the forest resources of the whole country.

Probably his greatest work for the cause of forestry consisted in laying a sure foundation for the graphic representation of forest activities and resources of all sorts. This was accomplished in the Forest Service Atlas, a monumental work of many volumes, which includes not only the topographic data usually associated with maps, but a wealth of diagrammatic and tabular information as well, which make it the best thing of its kind in the world. All future history of the forestry movement in the United States must invariably come to this source for the beginnings of a great deal of its information. His unusual genius showed particularly on the Forest Atlas, which represents his foresight, his large outlook, and his enthusiasm.

His colleagues in the profession always found it an inspiration to work with Plummer, and they recognize in him what the future will even more recognize—one of the real builders of forestry in this country.

Mr. Plummer's reputation as a geographer carried him into fields wider than those covered by the Forest Service Atlas. He was a member of the United States Geographic Board, and its chairman, Mr. Henry Gannett, has paid tribute to his great value in the work of that Board.

As a man he shone pre-eminent. His strong individuality and lovable character gave him a unique place in personal relations with his fellow-men, just as his ability and industry gave him prominence in his profession. It is probable that to those who knew Plummer as a friend, his scientific attainments, broad as they were, seemed only secondary, so great and so winning was the personality of the man. His good humor was unfailing and he radiated a spirit of kindliness and of thoughtfulness for others. As with all men of character, however, he had strong likes and dislikes and never surrendered to, or temporized with, that which he conceived to be wrong. Plummer's great capacity for friendship has been summed up by D. D. Bronson, his closest personal associate in the Forest Service:

"We who have been Plummer's co-workers in the Forest Service and in other scientific lines, while we will remember him as a scientist, as a philosopher, as a worker, as a helper, and as a splendid man and thorough gentleman, will also remember him as our friend, and the memory of Fred Plummer will encourage us in our endeavors and aid us in our efforts. While our loss is great, we may be sure that, in the words of the song, 'His soul goes marching on.'"

PROCEEDINGS

OF

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VOL. VIII OCTOBER, 1913 No. 3

REFORESTATION ON THE NATIONAL FORESTS

BY WILLIAM B. GREELEY

Delivered before the Society May 1, 1913

I will attempt in this paper simply a brief résumé of the reforestation work on the National Forests. Figures, bone dry like the standard weight of wood pulp, are of but incidental value in such a discussion and will be avoided as far as practicable. It will be of greater profit to summarize the more distinctive features of the reforestation work of the Service, emphasizing a few things which in a broad perspective stand out as specific accomplishments or form the more interesting contributions from this work of the Service to American forestry. It will be a statement of problems and difficulties fully as much as one of results.

In a review of the reforestation work of the past ten years on National Forests, three general stages, representing fundamental differences in policy, are apparent. The first was the attempted afforestation, in response to local needs for wood or cover of lands below the timber belts, notwithstanding the climatic and other difficulties to be overcome. In fact, with genuine American grit and sportsmanship, the most difficult localities were undertaken first, like the Nebraska sandhills, the chaparral slopes of southern California, and treeless or practically treeless watersheds in Arizona and New Mexico. Repeated efforts were made to solve the problems of afforestation where the need of it was most critical; hence, under practically the most adverse conditions existing on any portions of the National Forests. With the hindsight of ten years' experience, it is readily apparent that a large part of the work attempted

against such obstacles as the prolonged drought and intense heat of the southern California summer was necessarily doomed to failure, and that it would have been preferable to develop successful methods and learn their limitations upon more favorable areas first before attacking lands where forests were never produced by nature. Yet the final success of the plantations in the Nebraska sandhills, after years of unremitting effort, go a long way toward justifying the faith and perseverance of our planting pioneers.

The second stage in the reforestation work of the Service was marked by an effort to cover large areas annually, chiefly by the direct sowing of tree seed. In accordance with the personal convictions of Secretary Wilson, the cautious policy previously followed as to the scale of work and of expenditures was abandoned. In his belief that the denuded lands in the National Forests could be restocked rapidly and cheaply by direct seeding, the Department embarked upon the policy of extensive, rather than experimental, operations, with the purpose of reforesting the treeless lands in the National Forests within a given period of time. Secretary Wilson himself said that the work ought to be done in 50 years. Operations were therefore organized on a scale of from 25,000 to 30,000 acres annually, over three-fourths of which was to be seeded directly.

Whatever criticism may be justly made of this policy, the effort to which it committed the Forest Service has had many distinct advantages. It definitely made reforestation the work of the whole Service, rather than of a handful of devoted and somewhat despised specialists. It brought the entire field force of the National Forests to bear on reforestation; it woke them up to its importance; it aroused their interest and set their minds to work on the problems involved. A hundred interesting illustrations of this awakened interest and energy in the rank and file of the Service could be cited. A ranger in Montana invents a seed-threshing machine, patterned after the grain threshers of his former acquaintance. A timber cruiser has invented an improved seed-planter, made up of a rake for shallow cultivation with a hollow handle for holding and dropping the seed. Reconnaissance crews map and report the areas adapted to planting, as a resource to be included in their inventory of a forest in importance equal or almost equal to the forties of mature Douglas fir or yellow pine timber. In a word, the Service has been equipped in the most effective way, through training and interesting its entire personnel, to conduct this work in the future on almost any scale which may be desired.

Secondly, the Forest Service learned rapidly, under forced draught, much about technical and administrative methods which would otherwise

have come slowly. The cheap extraction and storage of seed on a large scale, the best season and methods of sowing, the handling of rodents, the organization and equipment of field planting crews, the routine of accounting, the systematizing of records and reports, inspection, and other features of administrative control—in these and similar matters the Service has forged ahead by great strides because of the necessity of handling a large volume of work, even although not adequately prepared for it.

Finally, as I shall discuss more fully a little later, this effort of the past four years has accomplished something real and definite in the actual reforestation of denuded lands.

Its serious defect has been the expenditure of large sums for this work before certainty of results was assured. It has not been unlike ordering a thousand flying ships before being sure that the model would fly. The scale of work attempted has also been too great for the resources of the Service and has necessitated some sacrifice in meeting more urgent, immediate demands, particularly the development of the most effective fire protection. Furthermore, the pressure to turn out a large acreage each year necessarily dominated the work and prevented as much and as thorough experimentation as was needed to adequately develop technical methods.

The policy of the Forest Service is now undergoing changes in this regard which are sufficiently fundamental to mark the entrance of a third stage. In this stage the emphasis will be placed primarily upon the experimental phases of reforestation, with the primary object of developing sound and certain methods applicable within reasonable limits of control, as the first essential, and thereby to equip the Service for future work on as extensive a scale as our organization and resources will justify, with certainty as to its results. The Investigative Program of the Forest Service for 1912 contained 86 distinct projects dealing with various phases of reforestation, and the program for the present calendar year contains 157 such projects. These are aside from the areas of more than experimental size which will be seeded or planted, and indicate the thoroughness and scope of the experimental work which is to be done as the corner-stone of our reforestation policy.

At the same time the Forest Service recognizes the necessity for a definite, progressive restocking of denuded lands within the National Forests. Congress and the people expect it; and Secretary Wilson was absolutely right in his position that the Service should go aggressively after concrete results in acres reforested. The policy of extensive work will therefore be continued, but on a more moderate scale, or approxi-

mately 20,000 acres annually, as determined by what we can do well with the funds and the organization available, under the methods, whatever they may be, which have been found best adapted to each site. The choice of technical methods will be governed wholly by the actual results of former experiments. The development of our nursery equipment is giving us much greater freedom than hitherto in the selection of methods. Direct seeding will be continued where it has been found successful; elsewhere it will be discarded and the work restricted to field planting until a cheaper method of equal success may be developed by experiment. The scale of work attempted in any District or National Forest will be enlarged or reduced as the actual results may indicate that we are or are not ready, with the methods as yet developed, to undertake those particular areas with reasonable certainty as to the outcome. Thus in District 3 and District 5, reforestation for the present will be conducted on an experimental scale only, and the major work will be restricted to other Districts where past results warrant operations on a larger scale.

Including the reseeding and planting of fail places, the work of the Forest Service up to January 1, 1913, covered a total of 81,730 acres; 65,740 acres of this aggregate were seeded and 15,990 acres planted with nursery stock.

Direct Seeding

With this general introduction, I wish to take up certain phases of the reforestation work, discussing first direct seeding; second, nursery work and planting, and concluding with a brief comparison of the results obtained under these two methods.

Our staple tree in direct seeding has been western yellow pine in its native timber belts. The great bulk of the area seeded has been with this species in its northeastern range on the Black Hills, Sioux, and Custer National Forests; in its northern range in western Montana and central Idaho, and in the timber belts dominated by this species in Colorado, Utah, California, and the Southwest. Second in scale of importance comes the seeding of Douglas fir, first, on the west slope of the Cascades and Coast ranges of Oregon and Washington; and, secondly, along the backbone of the Rocky Mountains. The third species in amount of use is lodgepole pine, which has been sown extensively throughout the central and northern Rocky Mountains. Sugar pine in northern California, particularly in the brush fields, into which forested areas have been turned as the result of repeated fires; Idaho white pine on the burns of northern Idaho, red pine in the Michigan sand plains, and red oak and walnut on the moist ranges of western Oregon and northern Idaho

are the other principal commercial species native to the United States which have been extensively used in this work. Under the pressure to obtain seed quickly at a time when the supply of American seed obtainable was wholly inadequate for the scale of operations demanded, the Service turned with some reluctance to European species. Austrian pine was sown on the Black Hills and on dry sites in Colorado and Utah. Norway spruce was tried extensively in the high timber belts of the southern Rockies, home of the Engelmann spruce, and on moist areas in the western Cascades. European larch and Scotch pine were tested on large areas in western Oregon and Washington, and the latter in small quantities on the central Rocky Mountain forests and in the Michigan pineries, and last but not least maritime pine was thickly sown on barren, sandy areas in the Florida National Forest.

The first duty of the Forest Service was to develop an organization, tools, and methods which would sow these tons of seed cheaply, with the maximum amount of pains possible under our limitations as to funds and field organization available for this work. This has been partly a question of weighing the respective merits as to cost and results of broadcast seeding without preparation of the ground, broadcasting on lands harrowed or roughly scarified by other methods, and planting in spots with varying degrees of preliminary working of the soil. It has been partly also a problem of organized and systematic seed collection and extraction under the best conditions for obtaining cheap seed. It has been chiefly, however, a problem of good business organization, of the handling of labor usually in inaccessible districts and in all sorts and conditions of weather, of the construction of trails, of the establishment and provisioning of camps and the maintenance of good foremanship in the direction of the work. In this phase of the problem, that of handling a large volume of work at a low and in fact steadily reducing cost, the Service has made a distinct record of efficiency. Extensive cultivation of the ground preliminary to seeding, by harrowing, disking or rougher methods approaching these, had to be discarded on a general scale on account of their excessive cost. With this exception, however, the methods employed have become more rather than less intensive and broadcasting or spotting without preliminary working of the soil has been almost wholly discontinued. Yet the cost of the work has been steadily reduced.

During the last two fiscal years the average cost of direct seeding, including seed, rodent poisoning, and preparation of the ground, has been $4.08 per acre and $4.10 per acre respectively. The work of the calendar year 1912 was done for an average cost of $3.86 per acre in District 1,

where the largest areas were handled, bringing its average down to $2.37. The earlier work in direct seeding cost the Service from $6 to $11 per acre. In practically every District there has been a progressive reduction in cost as the organization has been perfected in all of its parts.

Now for the obstacles which have been encountered. Probably the most serious, first and last, is the destruction of seed by rodents. It has been made clear by the exceedingly effective work of the Biological Survey and observation of many individual experiments that thorough and repeated poisoning in advance of seeding is essential to any measure of success except on recent burns where extensive forest fires have done the work of the poisoning. Various poisoned grains have been found effective if distributed over the tracts, at least twice at intervals of two or three weeks, before the tree seed is sown. Each area, however, is a problem in itself, requiring close study of the mammals present, their natural foods, their habits as to seasons of hoarding, and the like. One thorough poisoning in Montana, for example, proved ineffective apparently because the grain was scattered during the hoarding season of the particular rodents infesting the area, and was promptly carted off to add to the season's stores instead of being eaten.

Poor germination is the second of the major difficulties encountered in direct seeding. This bears a direct relation to the wet and dry seasons of the Western States and hence to the time of year when seed is sown. As a general rule, fall seeding has been the most successful. With several months of rain, snow, and frost heaving to work it into the ground, the seed has the best chance for early germination in the following spring. Many actual tests show that fall-sown seed germinates as a rule from four to six weeks earlier than seed which is sown when the ground is exposed in the spring. The young seedlings are thereby enabled to secure the maximum benefit of the wet season in root growth, and hence to fortify themselves for the hard struggle with their first summer drought, the most critical period in their entire life. The method of sowing is another factor of primary importance in securing good germination. In general, some method of cultivation whereby the seed is worked into loose mineral soil and covered has been found essential. A comparison of results from a series of seedings in District 2 forms an interesting illustration of this point. Broadcasting seed without preparation of the ground gave a success of 10 per cent; broadcasting on the snow, 17 per cent; thrusting into the ground with corn-planters, 25 per cent; broadcasting on harrowed soil, 27 per cent, and planting in worked seedspots, 36 per cent. The results of our past work have been so conclusive that seeding without some form of rough cultivation is now prac-

tically abandoned. The great majority of the seed is now planted on small spots where the soil is worked loose by rake or mattock.

After successful germination, the great danger which lies in wait for the luckless seedling is parching during its first summer's drought. Success or failure in weathering this critical period is often due to the climatic peculiarities of the individual season. Wet springs yield high percentages of success, while scarcely no seedlings, either naturally or artificially sown, can pull through such a spring as that of 1910. Aside from this factor of variable climate, which is beyond human control, loss from death during the first dry season can be prevented in part by the forester. It is directly related to the selection of planting sites, their elevation, aspect, and location with reference to the natural zone of the species used. It is affected directly by the amount of protective cover, in the form of weeds, dead timber, or down logs on burns, brush, advance growth of aspen, and the like. Our men are learning that to restock successfully by direct seeding they must utilize every advantage of this character, however minute, which will give the little seedling or group of seedlings that much more help in holding its own during the first summer. This is one of the fine points of the game. It applies not only to the selection of planting sites at the outset, which is of fundamental importance, but to the location of the individual spots. Wherever a log, a bush, a mound of earth, or the like, will afford a little protection, the north or east side of that little projection is the place to stick the corn-planter or rake the spot.

We are appreciating also more and more the limitations upon the selection of species. With the exception of small plots of Scotch and Austrian pine in the Rocky Mountain States and the sowings of maritime pine in Florida, European species have failed signally in coping with the rigorous summer climate of most of the National Forests. This is especially true of the large sowings of Norway spruce, European larch, and Scotch pine made in western Oregon and Washington; and we are restricting the choice of native species more and more closely to the hardier trees of the specific locality, even if of secondary present commercial value. With our experience with all of the difficulties to be overcome, we are realizing more and more that adaptation to the site conditions is the first essential, and that relative economic value is secondary. Some of the more despised trees, like lodgepole pine, in parts of the Rocky Mountain Districts are thus coming into their own because their hardy qualities and ability to overcome adverse conditions are worth more to us than the greater commercial value of possible competitors for selection, like yellow pine.

Some reforestation by direct seeding has been successful in every District. Areas restocked with yellow pine by this method may now be found on the Blackfeet, Lolo, and Bitterroot Forests in western Montana, on the Jefferson and Deerlodge in central Montana, on the Black Hills in South Dakota, and on a number of Colorado, Utah, and southern Idaho Forests. Stands of Douglas fir and lodgepole pine have been successfully established on scattered areas throughout the Rocky Mountains, extending from central Montana to southern Colorado and westward over portions of Utah and Idaho. A few successful sowings of Pacific Coast Douglas fir have been made on the Olympic and Siuslaw Forests. Red oak and walnut are being grown on the Cœur d'Alene in Idaho and on the Siuslaw near the Oregon coast. Some of the white-pine seedlings in western Montana are making a good showing, and the same can be said of a few very small areas of sugar pine in northern California. One of the most successful and interesting pieces of work is a 200-acre tract of maritime pine successfully grown by this method on the Ocala Division of the Florida National Forest.

The per cent of successful reforestation by direct seeding, based on a minimum stand of 200 trees per acre, varies between the National Forest Districts from about 7 to about 30 per cent. The work done in 1912 alone in one District gives indications to date of 60 per cent of successful stands. While no accurate approximation is possible, a close analysis of the results reported by the respective Districts indicates that of all of the direct seeding done by the Forest Service between 15 and 20 per cent has been reasonably successful.

The significant feature of this record is that the successful areas are by no means restricted to the most favorable sites, where soil and climatic conditions are most propitious. On the contrary, aside from California and the Southwest, the poorest results have been obtained where we would expect the best, in the favorable climatic zones of the Northwest. The best results have been obtained in southern Idaho, Utah, Colorado, and South Dakota, including many sites which in comparison with the deep soils and heavy precipitation of western Montana and the western slopes of the Cascades would be rated as distinctly unfavorable.

I attribute this discrepancy partly to the accident of good and bad seasons, and partly to the varying degrees with which the factors of rodents, quality of seed, methods and time of sowing, and the like, have been worked out and brought under control. Unquestionably, rodents alone are accountable for fully half of the list of failures.

Obviously, the whole story has not yet been told. If we can grow yellow pine by direct seeding in the Black Hills, there is no fundamental

reason why we cannot grow Douglas fir by the same method on the moist slopes of the western Cascades. Our past results are not conclusive as showing that direct seeding is a failure. On the contrary, they have shown that under the right combination of conditions, both under and beyond human control, forests can be established by direct seeding throughout the greater part of the total area under our administration. Our problem is now to ascertain by more intensive work on a smaller scale how often that necessary combination of factors can be practicably attained; to reduce the uncertainties and variables as far as may be possible to certainties; to bring the various factors under control, and hence to define the exact limits within which this method of forestation should continue to be used.

The past work in direct seeding has therefore simply blazed out a few main lines. The work must be restricted to the most favorable sites in each locality, usually to fresh burns well within the timber belts on cool aspects or at relatively high elevations. Only the hardier native species best adapted to successful growth under the local site conditions should be used. Rodents must be eliminated, either by recent fires or by repeated poisoning before the seed is sown. Fall planting in loosely worked ground is usually essential; and after all this has been done, success is subject to the hazard of exceptional drought during the following summer.

Within these broad limits, it will be the future work of the Service to define much narrower and more exacting limits adapted to each locality. This is primarily a problem for intensive experimentation; and our direct seeding in the future should be restricted much more closely to an experimental basis until the practicability of effective control of the many variables entering into the problem, and hence the future use which the Service should make of this method of forestation can be determined.

Nurseries and Field Planting

The nursery equipment of the Forest Service has been gradually developed to a point nearly if not entirely adequate for our needs during many years to come. With a total of 24 nurseries and something over 30 million seedlings and transplants of various ages, the Service is now prepared for the first time to give the use of nursery-grown stock the emphasis which it should have in our reforestation work as a whole.

Three different types of nurseries have been developed at different stages in the reforestation work of the Service. The first I will call the experimental nursery, run at a capacity of 300,000 plants annually or

less, in a region where planting is conducted on a small or experimental scale, or where from the location of the nursery but a restricted area of plantable land is within access. This is the type of nursery characteristic of the formative stages of our reforestation work in any given region, when things are conducted on a small scale and reforestation methods and policies are being cautiously developed.

The second type is a larger nursery, producing from one to three million plants annually, developed after planting has reached a somewhat definite basis on a larger scale in the group of forests surrounding the nursery. The size of such nurseries permits better equipment, better-paid personnel, and reduced unit costs of the planting stock produced.

The third type is the ranger nursery, smallest of the three, turning out but a few thousand plants annually. It is interesting to recall the conditions and point of view which led to the establishment, in 1905 and 1906, of a large number of such nurseries. It was partly as a measure of education to arouse the interest of the rank and file on the Forests in reforestation. Behind it also were strong technical and administrative arguments, based upon experience in many European forests. Chief among these is the advantage of producing planting stock locally, with local seed and under soil and climatic conditions as nearly identical as possible with those to be encountered in the final transplanting. Quick transportation to the planting sites is another obvious gain, while from the standpoint of cost it was hoped by this means to produce planting stock at a material net saving through utilizing the spare time of the regular personnel.

The success of the ranger nursery depended entirely upon the ranger. Nine men out of ten were not yet ready for it. The tenth man, who was a lover of the soil and of growing things, was ready for it and on him the effort was not wasted. A number of rangers of this type have with the right kind of help developed excellent little nurseries, meeting closely the ideals in mind when this movement was initiated. Some of the best stock grown anywhere in the Service has been produced in small quantities at these nurseries, and some of the best results in plantations have been secured in this way.

The middle-sized or experimental nursery, too big for a ranger and too small to employ the time of a planting expert profitably, necessarily means high cost of stock produced. The large, well-equipped nursery under good supervision, supplying a large tributary area with stock produced at low unit costs, has seemed, therefore, to be the logical development as the planting work becomes standardized in each region. The great bulk of our nursery operations are now centered at such establish-

ments. I am not at all sure, however, that there will not be a distinct place in the future work of the Service for the ranger nursery supplying a small area with home-grown stock produced within itself. Our men are ready for it from experience and education in this work as they were not seven years ago. Probably some expansion in our administrative organization will be necessary before any considerable number of rangers could undertake nurseries in addition to the multitude of other duties which now devolve upon them. Looking far ahead, however, I venture to prophesy that the ranger nursery shifting as the areas to be planted shift will find a distinct place in the organization.

Five medium-sized and large nurseries and seven ranger nurseries, with a total minimum capacity of 7,000,000 plants, are distributed throughout the Rocky Mountain region. Their product is made up largely of the staple commercial species of this region—lodgepole pine, Douglas fir, Engelmann spruce, and yellow pine. One large nursery and one ranger nursery, with a total capacity of about 3,000,000 plants, supply the upper Columbia drainage in Montana and northern Idaho, their chief products being western white pine, yellow pine, and larch. Two large nurseries and one ranger nursery are located in the Northwest Coast belt. Their capacity is 2,000,000 plants, chief among which is Douglas fir. One experimental nursery only is maintained in northern California for the sugar-pine belt, producing some 250,000 plants annually for purely experimental work with sugar pine, white fir, and other characteristic species of the region. Three experimental nurseries have been continued in the yellow-pine belt of the Southwest, including southern California, to work out on a small scale and under intensive methods the extremely difficult reforestation problems of that region; and three nurseries of varying size, producing annually 2,300,000 plants, to supply yellow, Jack, and Norway pine and other species for the Forests in Kansas and Nebraska. This system of nurseries covers practically all of the National Forest regions and, by enlarging its scale of operations, can fill the demands for stock created by almost any future increase in reforestation work.

Fully as essential as the completion of our nursery equipment has been the standardizing of nursery costs and their reduction to a point which will make the use of nursery stock on an extended scale sound and practicable from a business standpoint. This has to a very large degree been accomplished and it constitutes another essential foundation stone in the reforestation of denuded lands in the National Forests viewed in the broad.

For the fiscal year 1911 the Forester reported that a large part of the nursery stock used cost from $8 to $10 per thousand plants. During the last calendar year the standard species and age classes were grown in nearly all of the larger nurseries for less than $3 per thousand plants. The average cost of all of the stock used in District 4, mostly of the 2–0 and 1–1 classes, was $2.38 per thousand. The same District produced two-year seedlings of yellow pine, exclusive of distribution costs, for 82 cents per thousand plants and two-year seedlings of Douglas fir for 76 cents. The average cost of the stock grown at the Monument Nursery in Colorado was $2 per thousand plants and one of its standards, 1–1 yellow pine, was grown, exclusive of distribution costs, for $1.19. 2–1 Douglas fir was produced at the same nursery for costs ranging from $2.06 to $2.67 per thousand plants. Idaho white pine, for many years one of the hardest and most expensive trees to handle in the nursery, is now being grown at the Savenac Nursery in western Montana at $1.33 per thousand trees for two-year seedlings and $2.99 for transplants. All of these costs include prorated charges for overhead expenses, improvements, and maintenance of the nursery. The reduction in nursery costs is the largest factor in bringing down the total cost of plantations, and hence in making field planting feasible on a general scale.

Substantial progress in nursery practice, particularly in the elimination of losses, lies behind this gratifying reduction in the cost of the product, and, furthermore, are yielding better and stronger plants. Fall sowing has been adopted at many of the nurseries, where it has been found to result in earlier germination by a month or a month and a half and correspondingly larger stock at the end of the first growing season. This has also proved the solution of nearly every case of obstinate germination. Much has also been accomplished in hardening stock through reduced shade and water, so as to adapt it in advance to the conditions which must be encountered after transplanting.

Intensive study of nursery rotations has shown that for many of the more favorable sites, particularly where yellow pine is used, a large measure of success can be obtained with two-year seedlings, avoiding the cost of transplanting in the nursery altogether. Some of the larger nurseries in District 4 are now operated on this basis. An interesting phase of this method is the grading of nursery stock. With a given equipment of nursery ground and improvements and the minimum number of men required in any event to maintain the nursery, it is the policy to grow the maximum number of seedlings which can be produced under these conditions. The product may then exceed the stock which can be used in plantations by 30 or 40 per cent, but this excess is disposed of by

grading down the plants and utilizing only the best 60 or 70 per cent. The total cost is no more than it would have been had but the 60 or 70 per cent been grown at the outset, and the average quality is materially improved. A number of experiments with yearling yellow-pine seedlings have proved successful, and it is possible that very cheap plantations can be established on the most favorable sites with stock of this age and species. Similar experiments with all other species have been failures. With these exceptions, the results obtained indicate the desirability of continuing two-year stock, once transplanted, as the general standard and of adding a third year in either the seedling or transplant beds, which increases the cost but very slightly and adds greatly to the strength of the plant. Supervisor Koch advocates a 1–2 rotation for western white pine, and if, as the past results at the Savenac Nursery indicate, such stock can be produced for under $3 a thousand the plan should prove of decided advantage.

The tale of results of National Forest plantations is a wholly different one from that of the seeded areas. An analysis of the returns available indicates that stands have been successfully established on not less than 75 per cent of the acreage planted; and this is true with remarkable uniformity over a very large number of the National Forests where stock has been planted, with the exception of the arid parts of the Southwest. The success of many of the plantations is striking, particularly in view of the adverse conditions in the same locality which have rendered direct seeding so uncertain. A yellow-pine plantation on the west side of the Crater National Forest in Oregon, on an area where direct seeding was almost a total failure, now has over 91 per cent of thrifty seedlings. Douglas-fir plantations on Mount Hebo in the Siuslaw, where direct seeding has given extremely variable and uncertain results, range from 72 to 100 per cent. Eighty-two per cent has been obtained with yellow pine on the pumice soils of the Deschutes, where direct seeding failed utterly, and from 65 to 83 per cent with yellow pine on the Whitman and Malheur Forests, on areas where seeding resulted in a success of from 5 to 20 per cent. Perhaps the most striking of all is a series of plantations on the Pike National Forest in Colorado, conducted since 1910, and covering a total of 345 acres, where every plantation has been successful.

With the increasing success of National Forest plantations has come a material, although not yet adequate, reduction in their cost. This has been due largely to the decreased cost of growing stock in the nurseries. Other economies have been effected in planting in the field, particularly by the concentration of plantations on relatively few areas, where the

work can be conducted under the best conditions and with the most competent supervision. For the fiscal year 1911 the average cost of our plantations was $19.56 per acre. For 1912 the average dropped to $11.05 per acre for all species and to $10.73 for conifers, which formed the great bulk of the species used. During the calendar year 1912 as a whole recent reports received from the Districts indicate a further drop in the average total cost of the plantations, including the cost of nursery stock, to $9.90 per acre. The record at District 1 in this respect is rather typical. In 1909 and 1910 the work by seasons, considering each spring and fall as a distinct season, ranged between $13.15 and $35.40 per acre. The plantations in the spring of 1911 cost $12.75 per acre and in the fall of the same year $7.50. In 1912 the work was done for $6.75 and $7.36 for spring and fall, respectively.

The practicability of reforesting the greater part of the denuded lands on the National Forests by planting nursery stock has been fully demonstrated. There remains the weighing and testing of methods and costs to define the limits within which this work should be done as a practical administrative question in the expenditure of funds. This question must be decided not only from the standpoint of the degree of success obtainable on different kinds of land, but also in full consideration of the initial cost and the actual returns secured either in the production of timber or the protection of watersheds. Let me illustrate this point briefly. The cost of large plantations of Douglas fir last year, eliminating small areas whose costs are not indicative of what can be done on a more extensive scale, ranged on different Forests in various Districts from $5.22 per acre to $13.96 per acre, or from 1 to nearly 2.7. The cost of the larger plantations of yellow pine had a similar range of from $4.92 per acre to $14.38 per acre, or almost from 1 to 3. These differences in cost are not altogether, but in large part, due to differences in the actual physical conditions involved as to age and size of nursery stock required, care in planting necessary, inaccessibility of the planting sites, and the like. In other words, the problem which is presenting itself is: Should $15 be expended in planting one acre on a central Rocky Mountain Forest or three acres on a northwestern Forest? It will be a matter of but a few more years before the costs and the results in each National Forest region will be so definitely standardized that that problem can be put in terms of mathematical exactness. We can almost do it now.

When the problem can be expressed with such definiteness, a careful selection of regions and sites for future planting operations will be necessary. I will not attempt to indicate how that selection should be made. As a general policy, I believe that our plantations should be restricted

for the present to the more favorable sites until our methods are fully developed and their limitations as to cost and success more definitely known. Exceptions to this rule should be made in States like Nebraska, North Dakota, and Michigan, where National Forests have been established primarily for experiment and demonstration in reforestation. In such cases the work must be pushed to conclusive finality, whatever the adverse conditions which may be encountered, the unit cost involved and the limitations upon success. But for the bulk of the denuded lands in the National Forests as a whole, I feel that while continued experimentation in the less favorable and adverse localities is clearly advisable, our extensive work, the work on which we rely for our showing in acres actually restocked, should be confined to the more favorable sites until we have tried out our methods fully and know just what we can and cannot do with them and what it will cost. This applies, in my judgment, to plantations of nursery stock no less than to direct seeding. A corollary of this principle is the use of the hardier native species, rather than exotics or American trees of greater commercial value, until conclusive experiments have shown that the use of species of the latter classes is safe.

Comparison of Direct Seeding and Planting

To summarize briefly the comparative results of the past work in seeding and planting, we have apparently a maximum of 20 per cent of successful reforestation by direct seeding at an approximate cost of $4 per acre, as compared with 75 per cent of successful reforestation by planting at an approximate cost of $10 per acre. The area successfully restocked by seeding has therefore cost $20 per acre, while the area successfully restocked by planting has cost $12.50 per acre, a difference of $7.50 per acre in favor of planting. While detailed exactness cannot be claimed for these figures, they form, in my judgment, an approximate index of the actual results from the standpoint of cost. In contrast with this, however, I must cite a tabulation of 1,765 acres on the Pike National Forest, 345 of which were planted and 1,420 sown on prepared soils. On the basis of 775 trees per acre for the plantations and 500 trees per acre for the seeded areas, 100 per cent of the planting and 45 per cent of the seeding, respectively, were successful. The first cost was $14.20 per acre for planting and $7.29 per acre for seeding. Adding the cost per acre of reseeding and filling fail places gives a final cost per acre of $15.24 for planting and $13.34 for seeding, a difference of $1.90 per acre in favor of the latter method. This comparison can be put in a nutshell by saying that for the Service as a whole, at the present average costs at which this work is being done, only 30 per cent of success in direct seed-

ing is necessary to make this method cheaper for the actual area reforested than planting.

This purely tentative conclusion indicates clearly that the final word as to the use of these two methods in future reforestation work has not yet been spoken. It is unquestionably true that direct seeding should be restricted to the very best one-half or one-third of the denuded areas requiring reforestation. Whether within that one-half or one-third as well it should give way to planting with nursery-grown stock can only be determined after three or four years' more work have shown how far the variable and uncertain conditions affecting its success can be brought under control, and how far its results can be standardized generally on a scale of success approaching that hitherto obtained on only a small percentage of the more successful areas.

Future Place of Reforestation in the Administration of the National Forests

In conclusion, I wish to bring out a few points of relationship between the reforestation work of the Service and the administration of the National Forests as a whole. At least 5,000,000 acres of denuded lands capable of growing timber are awaiting artificial restocking in the National Forests to restore them to their most productive use. Right here is involved a possible increase of half a billion feet in the annual yield of timber.

The National Forests contain 1,175 watersheds which supply municipalities, 324 water-power projects, and 1,266 irrigation projects, aside from many other outside power and irrigation projects which are fed by watersheds within the Forests. The growing importance of the function of the National Forests in protecting water supply is evidenced by the public consideration now being given to flood control, by the request from many western cities for special measures to protect their municipal water supply, by the concern expressed by irrigation associations in Colorado and elsewhere over even the regulated cutting in National Forest sales from fear of lessening the available water supply, and by the rapid rate at which the development of the unused reservoir and power sites in the Forests is being undertaken. Reforestation is a primary essential to the effective discharging of this function of the National Forests.

Artificial reforestation, furthermore, is coming into demand as a feature of silvicultural management. It is already advocated in connection with cutting overmature stands of Douglas fir and Idaho white pine in the Northwest as safer and cheaper than the leaving of veteran seed trees past their maturity and of great market value. Unquestionably, as more

intensive methods of management are developed, artificial restocking of cut-over areas will figure largely in timber-sale methods in parts of the West, where natural regeneration can be secured only by excessive sacrifices in the harvesting of the present crop, or is precarious and long-delayed, as in the pine stands of Arizona and New Mexico.

I cite these patent facts simply as an antidote to the natural discouragement of the man on the ground who has in many cases witnessed failure after failure in spite of earnest and painstaking effort. We must not lose sight of the fact that reforestation is one of the big permanent tasks of the Service on the National Forests, and that in the long run it will be the greatest and best-paying permanent improvement of the Forests which we could bring about. It has taken a deal of optimism, of bull-dog tenacity, and of refusal to be beaten, or at least to admit it, to carry on this work; but all the effort expended is justified by the ultimate results which will be accomplished.

THE USE OF FRUSTUM FORM FACTORS IN CONSTRUCTING VOLUME TABLES

BY DONALD BRUCE

Contributed

In the June, 1912, number of the Forestry Quarterly was published an article entitled "A New Method of Constructing Volume Tables," which suggested the use of frustum form factors in such work to reduce the number of tree measurements necessary for satisfactory results. During the past few months the writer has had available a considerable number of tree measurements of western white pine which have yielded very interesting results when treated in accordance with the methods outlined in that article. In general, these seem to show very conclusively that satisfactory tables can be made by that method from a far smaller number of trees than was previously considered possible.

Two volume tables for the species were made by two different methods. The first was based on but 25 trees, and without any pretense at accuracy was intended merely to show what could be done with such meager data. The trees selected were just such as would be readily available to any one who might find it necessary to construct a local table at the least possible expense. All the measurements were carefully taken by a yield table crew, but for this first table those chosen were from one small drainage on the Cœur d'Alene Forest, Idaho, and even from one age class within that drainage. The method employed was as follows:

(*a*) The following table, Table 1, of frustum volumes, was prepared showing the volumes in feet b. m., when scaled by the Scribner rule in 16-foot lengths, of frustums of cones having a top diameter of 6 inches, a bottom diameter equivalent to d. b. h. inches from 8 to 40 inches and heights in even 16-foot lengths up to 160 feet (except that 20 feet is substituted for 16). The top diameters of the different sections were calculated to the nearest 0.1 of an inch and interpolations were made in the Scribner rule to the same degree of accuracy. The substitution of a 1¼-log height column for the usual one-log column is consistent with the usual custom in estimating which does not consider any tree less than one log in height, and hence groups together trees varying from one to one and one-half logs.

TABLE 1

Volumes of Frustums of Cones

Scaled as 16-foot logs, Scribner rule

D. B. H.	Height in logs. 1¼	2	3	4	5	6	7	8	9	10
8	25	46	72	99	....	....	....	....	....	....
9	25	48	78	107	....	....	....	....	....	....
10	26	50	85	118	....	....	....	....	....	....
11	27	54	92	130	168	....	....	....	....	....
12	28	58	100	145	190	233	....	....	....	....
13	29	63	113	162	213	264	312	....	....	....
14	30	68	126	179	239	296	351	409	....	....
15	32	75	137	201	266	329	395	459	523	....
16	34	83	153	224	293	371	445	518	593	665
17	36	90	168	249	333	416	493	578	661	742
18	38	97	182	279	367	452	551	643	735	826
19	40	106	205	302	403	507	610	710	813	918
20	42	115	226	332	445	561	665	786	899	1010
21	44	123	242	362	492	609	740	860	987	1116
22	46	132	265	395	533	670	814	945	1089	1219
23	50	146	287	433	583	737	882	1028	1179	1332
24	51	160	310	470	634	796	949	1123	1279	1450
25	53	168	337	515	680	855	1034	1218	1391	1567
26	55	177	362	546	729	927	1127	1304	1499	1683
27	61	190	395	579	793	1002	1200	1403	1630	1832
28	64	203	417	631	851	1072	1297	1529	1752	1967
29	72	217	441	677	920	1154	1421	1639	1866	2120
30	..	231	466	714	989	1229	1503	1748	2003	2273
31	..	244	504	772	1046	1322	1592	1859	2142	2398
32	..	258	537	825	1115	1403	1685	1967	2266	2546
33	..	278	564	883	1181	1476	1780	2100	2405	2728
34	..	298	607	943	1241	1572	1886	2233	2556	2885
35	..	310	645	984	1303	1665	2012	2344	2678	3022
36	..	322	677	1022	1371	1756	2112	2454	2820	3189
37	..	337	718	1068	1461	1836	2211	2578	2967	3337
38	..	352	753	1123	1532	1925	2305	2686	3116	3514
39	..	374	785	1199	1604	2005	2420	2870	3272	3690
40	..	395	812	1246	1683	2088	2560	3000	3430	3901

(*b*) The following tabulation of the 25 trees which were selected at random was then prepared:

TABLE 2

D. B. H. Inches.	Merchantable height. Logs + feet.	Volume as scaled. Feet b. m.	Volume of corresponding frustum. Feet b. m.	Frustum form factor.
21.4	7 + 9	84.5	83.2	1.01
22.6	8 + 2	105.0	101	1.04
24.1	8 + 15	127.5	149.7	.85
16.8	6 + 9	50.5	54.6	.93
16.8	7 + 5	72.5	69.2	1.05
15.3	6 + 12	44	49	.90
21.6	7 + 13	78.5	89	.88
16.4	6 + 6	43	42	1.02
18.9	7 + 11	70	67	1.04
21.7	7 + 14	95.5	90	1.06
16.7	6 + 14	51	50	1.02
21.3	7 + 10	101.5	83	1.22
21.6	8 + 3	106.5	94	1.13
18.4	7 + 6	59	61	.97
17.2	7 + 7	58	54	1.07
14.7	6	30	32	.94
19.1	7 + 12	78	69	1.13
16.5	7	53	47	1.13
13.6	5 + 3	23	24	.96
14.4	5 + 8	32	28	1.14
19.8	7 + 3	62.5	68	.92
14.9	6 + 1	36	33	1.09
15.9	6 + 12	38	42	.90
14.6	6 + 4	41	33	1.24
12.4	4 + 7	15.5	17	.91
Average	.....	....	....	1.02

The volumes in the fourth column were taken from Table 1 by interpolation both for diameter and height. Column 5 represents the ratio between the figures in columns 3 and 4.

(*c*) The values in Table 1 applicable to this species were then multiplied by the average frustum form factor resulting from Table 2 to give the resulting volume table, the values of which are given in Table 3, preceded by the letter "A."

TABLE 3

Frustum Form Factor Volume Tables—Western White Pine

A = values based on 25 trees
B = values based on 160 trees

D. B. H.		Height in logs. 1¼	2	3	4	5	6	7	8	9	10
8	A......	25	47	73	....	....	....	....	....	....	....
	B......	26	48	75	....	....	....	....	....	....	....
9	A......	26	49	79	....	....	....	....	....	....	....
	B......	26	50	81	....	....	....	....	....	....	....
10	A......	27	51	87	120	....	....	....	....	....	....
	B......	27	52	88	123	....	....	....	....	....	....
11	A......	....	55	94	133	171	....	....	....	....	....
	B......	....	56	96	135	174	....	....	....	....	....
12	A......	....	59	102	148	194	232	....	....	....	....
	B......	....	60	104	151	197	242	....	....	....	....
13	A......	....	64	115	165	217	269	....	....	....	....
	B......	....	65	117	169	221	274	....	....	....	....
14	A......	....	69	128	183	244	302	....	....	....	....
	B......	....	71	131	186	249	309	....	....	....	....
15	A......	....	....	140	205	271	335	....	....	....	....
	B......	....	....	142	210	276	342	....	....	....	....
16	A......	....	....	156	228	299	379	....	....	....	....
	B......	....	....	159	232	304	385	....	....	....	....
17	A......	....	....	171	254	340	423	503	589	....	....
	B......	....	....	173	257	343	427	508	595	....	....
18	A......	....	....	182	285	374	461	562	655	....	....
	B......	....	....	185	288	378	465	567	662	....	....
19	A......	....	....	....	308	411	517	622	724	....	....
	B......	....	....	....	311	415	522	628	730	....	....
20	A......	....	....	....	339	453	573	678	802	....	....
	B......	....	....	....	342	458	578	685	810	....	....
21	A......	....	....	....	369	502	621	755	877	1007	....
	B......	....	....	....	373	507	627	762	885	1017	....
22	A......	....	....	....	403	544	683	830	964	1110	....
	B......	....	....	....	407	549	690	838	973	1122	....
23	A......	....	....	....	....	595	751	898	1048	1202	....
	B......	....	....	....	....	602	758	908	1060	1214	....
24	A......	....	....	....	....	647	812	968	1145	1303	....
	B......	....	....	....	....	651	817	975	1153	1313	....
25	A......	....	....	....	....	694	872	1055	1243	1420	....
	B......	....	....	....	....	694	872	1055	1243	1420	....
26	A......	....	....	....	....	743	945	1148	1330	1530	....
	B......	....	....	....	....	743	945	1148	1330	1530	....
27	A......	....	....	....	....	809	1022	1224	1431	1662	....
	B......	....	....	....	....	800	1012	1212	1418	1645	....

Frustum Form Factor Volume Tables—Western White Pine—Continued

D. B. H.		Height in logs.									
		1¼	2	3	4	5	6	7	8	9	10
28	A......	....	....	....	....	868	1093	1323	1559	1786	....
	B......	....	....	....	....	850	1070	1300	1530	1750	....
29	A......	....	....	....	....	....	1176	1449	1671	1902	....
	B......	....	....	....	....	....	1145	1410	1625	1850	....
30	A......	....	....	....	....	....	1253	1533	1782	2043	....
	B......	....	....	....	....	....	1204	1475	1715	1970	....
31	A......	....	....	....	....	....	1348	1624	1896	2185	2446
	B......	....	....	....	....	....	1285	1545	1805	2080	2325
32	A......	....	....	....	....	....	1431	1713	2006	2311	2596
	B......	....	....	....	....	....	1360	1635	1910	2200	2470
33	A......	....	....	....	....	....	1505	1816	2142	2453	2782
	B......	....	....	....	....	....	1402	1691	1995	2285	2592
34	A......	....	....	....	....	....	1603	1924	2277	2607	2943
	B......	....	....	....	....	....	1495	1770	2120	2425	2740
35	A......	....	....	....	....	....	1698	2052	2391	2732	3082
	B......	....	....	....	....	....	1548	1871	2180	2490	2810
36	A......	....	....	....	....	....	....	2156	2503	2876	3251
	B......	....	....	....	....	....	....	1965	2280	2625	2970
37	A......	....	....	....	....	....	....	2255	2629	3026	3404
	B......	....	....	....	....	....	....	2012	2346	2700	3077
38	A......	....	....	....	....	....	....	2351	2740	3178	3584
	B......	....	....	....	....	....	....	2100	2445	2835	3200
39	A......	....	....	....	....	....	....	2468	2927	3337	3764
	B......	....	....	....	....	....	....	2178	2583	2945	3321
40	A......	....	....	....	....	....	....	2611	3060	3498	3979
	B......	....	....	....	....	....	....	2310	2705	3090	3515

The second table was constructed from a larger number of trees, 160 in all, which were taken from a wider range of conditions: A part were from the same stand as that mentioned above, while others were from Big Creek on the St. Joe Forest, Idaho. The former were all about 110 years old and averaged about 18 inches in diameter, while the latter were considerably over 200 years in age and averaged 24 to 36 inches in diameter. The method employed was the same as that above described up to the completion of a tabulation, such as is shown in Table 2 (the table in this case is too lengthy to be given here in full). The frustum form factor values in this table were then averaged by a 2-inch diameter class and evened off by means of a curve, giving the results shown in Table 4.

TABLE 4

D. B. H. Inches.	No. of trees.	Average frustum form factor.	Same curved.
11 } 12 }	5	1.01	1.04 / 1.04
13 } 14 }	10	1.05	1.04 / 1.04
15 } 16 }	20	1.02	1.04 / 1.04
17 } 18 }	19	1.02	1.03 / 1.03
19 } 20 }	23	1.08	1.03 / 1.03
21 } 22 }	23	1.01	1.03 / 1.03
23 } 24 }	13	1.03	1.03 / 1.03
25 } 26 }	19	1.03	1.02 / 1.02
27 } 28 }	11	1.02	1.01 / 1.00
29 } 30 }	3	1.03	.99 / .98
31 } 32 }	10	.99	.97 / .97
33 } 34 }	3	.81	.96 / .95
35 } 36 }	..	....	.94 / .93
37 } 38 }	1	.86	.92 / .91
39 } 40 }	..	....	.90 / .90

It will be observed that the 160 measurements used were not sufficient to give an entirely satisfactory basis for a curve, and it was necessary to check the latter carefully by grouping the values together in 4 and 8 inch diameter classes. The essential accuracy of the results is, however, proven by the checks later to be described.

The final volume table was prepared by multiplying the values in Table 1 for each diameter class by the corresponding frustum form factor from Table 4. The results are given in Table 3, preceded by the letter "B."

The accuracy of the two volume tables was then tested by checking them with 80 trees taken at random. For purposes of comparison, two other volume tables were available, both constructed in the conventional

way. One was compiled on the Kaniksu Forest, Idaho, in 1908, based on 1,791 trees, and the other one recently constructed on the St. Joe Forest, Idaho, based on between 700 and 800 trees. The latter was, like the two tables above given, based on utilization to a uniform 6-inch top, but the Kaniksu table was based on trees cut to a top diameter ranging from 6 to 8 inches. It should be borne in mind in considering the following figures that this latter point tends, when used to compute trees estimated to a 6-inch top, to give values considerably too high, thus making the error shown even more serious than would at first appear. The 80 check trees were taken, as would be the case under actual field conditions, from one stand, that above mentioned on Big Creek and from a 200-year plus age class. In comparing the figures the following points should be borne in mind:

(A) That the first frustum form factor table was based entirely on trees of a different age class and of such a size that the largest tree was only about equal to the average of the trees checked. This meant that the table had to be prolonged from 24 inches to 37 inches, about as severe a test as could be made.

(B) That the second frustum form factor table, while based partially on trees of the same character, also depended equally on the entirely different age class from Eagle Creek.

(C) That the Kaniksu table was based on a much larger number of trees taken from a location within 100 miles of that in which the check trees grew.

(D) That the St. Joe table was actually based upon trees largely from within the same drainage and almost entirely from within the same age class as the check trees.

Table 5 gives the result of this check.

TABLE 5

Check of Four Volume Tables by 80 Trees Taken at Random from Big Creek, St. Joe Forest, Idaho

Table.	Method of construction.	Basis No. of trees.	Approximate cost of table.	Computed scale feet, b. m.	Error per cent.
Kaniksu..	Conventional	1,791	$600.00	78,285	−14.5
St. Joe....	Conventional	700	250.00	98,890	+ 7.9
Table A..	Frustum form factor average value for all heights and diameters.	25	8.00	93,629	+ 2.1
Table B..	Frustum form factor average value for each d. b. h. class.........	160	40.00	91,724	+ 0.08
	Actual scale.......	.....	....	91,650	....

These figures speak for themselves. Even the cruder of the frustum form factor tables gives only one-fourth the error of the better of the conventional tables, although based on trees from a stand of widely differing character from that of the check trees. The fourth column but emphasizes the contrast. The costs given are estimated for the Kaniksu and St. Joe tables, but in the case of the latter two the time required was carefully kept, both field and office work being included. The cost of compilation of the table of frustum values (Table 1) is not, however, included, since this once completed is available for any number of species, provided only that the log rule and the degree of utilization are the same. The total cost of this amounts, however, to but about $3.

Of course, it is entirely possible that the abnormally close figures obtained for Table B might be merely a coincidence, since 60 trees are hardly a sufficient number to be absolutely conclusive. The decided possibility is also suggested that the trees from which the Kaniksu table was compiled actually had a markedly different form factor from those involved in this first check. A second check was therefore conducted, in which were used 50 trees taken at random from a number of measurements gathered on the Kaniksu Forest. The heights of these trees were so different from those previously used that the St. Joe table was practically useless. In this case, furthermore, allowance was made for the range of the top diameters in the table by preparing a second tally sheet, in which the heights in logs were taken to the variable instead of to the constant 6-inch top. An allowance of an 8-foot 6-inch log for each tree which was thus changed in height class was then deducted from the total actual scale. The results follow:

TABLE 6

Check of Three Volume Tables by 50 Trees Taken at Random from the Kaniksu Forest, Idaho

	Scale feet, b. m	Error.
By Kaniksu table (heights of trees taken to range of tops consistent with table)	26,475	−13%
By Table A	32,605	+ 7%
By Table B	32,929	+ 8%
By actual scale to 6″	30,530	
By actual scale to range of top diameters	30,360	

It is very apparent that there is a fundamental difference of form between the white pine of the Kaniksu and that of the region tributary to Cœur d'Alene Lake. This difference existing, of course no table can be constructed by any method nor based on any number of trees, no matter how large, which will be satisfactory in both localities. The point to be noted is, however, that even when applied the trees from the very Forest

from which its own data were taken, the table constructed in the conventional way from nearly 2,000 trees, shows a greater error than that constructed by means of frustum form factors from alien data, less than one-tenth as extensive. The fairer comparison is between the 13 per cent error of the Kaniksu table in this second check and the 0.08 per cent error of Table B in the first.

A third check was then made, which was based on a sufficient number of trees to eliminate the possibility of accidental results on account of limited data. More than 380 trees were gathered from all parts of the white-pine region and tallied by the Kaniksu table and by the more accurate of the frustum form factor tables (Table B). The results were as follows:

TABLE 7

Check of Two Volume Tables by 380 Trees from all Parts of Western White Pine Region

Actual scale	291,753
Scale by Kaniksu table	249,730
Scale by frustum form factor, Table B	285,123
Error by Kaniksu table	−14.4%
Error by Table B	− 2.2%

The contrast is strikingly in favor of frustum form factor table, and would be still further marked if the trees had been tallied to the variable top for use with the Kaniksu table, as in the previous case. It is estimated that this would have increased the error from 14.4 per cent to approximately 20 per cent.

The foregoing checks appear to establish quite convincingly the essential accuracy of the frustum form factor method when applied to whole stands or groups of trees of considerable size. It might be claimed that there is a possibility of a considerable error in individual values which would be compensatory when a number of tree scales are combined. This possibility results, of course, from the assumption that a single frustum form factor value is reasonably accurate for a whole diameter class. To investigate the soundness of this assumption, 400 trees were analyzed. To shorten the compilation these were grouped by diameters and height classes, the average d. b. h. and height for each class noted, and frustum form factors obtained by classes rather than by individual trees. The resulting table was entirely inconclusive. Large variations occurred, showing that the data were inadequate and no definite conclusions could be reached as to the laws, if any exist, which govern frustum form factors except that the values decrease with the increase in d. b. h. (This is undoubtedly due to the gradual rise of the root swelling up to and past

the point of diameter measurement.) One point, however, was of extreme importance, even though negative rather than positive in character, and that was that no definite relation could be observed between the frustum form factor values and the height classes. The average value for the 2 to 5 log class (112 measurements) was 1.05 and for the 6 to 10 log classes (288 measurements) was 1.03, but this small difference is probably chargeable to the fact that the higher log classes represent a much larger average d. b. h. Within individual d. b. h. classes no consistent difference could be seen. While the values of one class might appear to increase with the height, those of the next would decrease and the next perhaps be almost uniform. It seems a safe assumption, then, that even if an average value for each d. b. h. class is not absolutely accurate for all the height classes within it, the variation from this value must be quite small or this analysis of over 400 trees would have brought it to light, and therefore that no serious error for any ordinary purposes is introduced through this assumption.

The accuracy of the cruder method described is apparently so surprisingly great that the minimum number of trees from which a volume table of reasonable accuracy can be constructed by it is a point of considerable interest. The most practical method of investigation involves the application of one of the formulæ for the probable error of the average value of a group of measurements based on the theory of least squares. The simplest to apply is the approximation formula,

$$E = \frac{.8453 \; Sv}{n \sqrt{n-1}}$$

where E is the probable error, Sv the sum of the deviations of the individual values from the mean, and n the number of values. Applying these, for example, to the trees in Table 2, Sv is 215 and n 25, and E is found to be .0148; in other words, there is an even chance that the average value, or 1.02, obtained from that group of 25 trees is within less than 1½ per cent of the correct value. Six other groups of 25 trees all showed a probable error of less than 2 per cent, indicating that for this particular species that number is fairly satisfactory. Preliminary work on other species indicated, however, that in the case of thick-barked trees and those having an exceptionally heavily buttressed form, such as western red cedar and western larch, considerably more measurements will be necessary to give a satisfactory average. The safe method would be to check each group of measurements collected by the above formula before use.

It is freely admitted that the data submitted herewith are not entirely conclusive. A large amount of further investigation, not only of the western white pine, but of a wide range of species, is necessary before final conclusions can be reached. It may be mentioned that preliminary work has been done on western larch and lowland fir, and that the results though comparatively meager are confirmatory of those above tabulated; but while the data herewith presented represents hardly more than a preliminary survey of a large field of investigation, it seems to justify the following conclusions:

(1) That by the use of the frustum form factor method first described a volume table of a quite satisfactory degree of accuracy can be constructed with a very small number of tree measurements—as few as 25 in the case of the western white pine—and at very small expense.

(2) That at a slightly greater expense and with a somewhat larger number of measurements a table can be constructed by the second method in which the error is practically negligible.

(3) That, as compared to the conventional method, even the cruder frustum form factor method gives much more accurate results, and even the more laborious involves but a fraction of the expense.

DARWINISM IN FORESTRY

BY RAPHAEL ZON

Delivered before the Society May 1, 1913

The centennial anniversary of the birth of Charles Darwin was the occasion for many interesting reviews of what Darwinism has done for the biological sciences. In all these reviews, however, scarcely any reference is made to forestry. Yet historically and inherently there is a most remarkable and unique connection between Darwinism and forestry.

On April 10, 1860, soon after the appearance of the first edition of the "Origin of Species," Darwin wrote to his friend C. Lyell:

"Now for a curious thing about my book, and then I have done. In last Saturday's *Gardeners' Chronicle,* a Mr. Patrick Matthew publishes a long extract from his work on 'Naval Timber and Arboriculture,' published in 1831, in which he briefly but completely anticipates the theory of natural selection. I have ordered the book, as some few passages are rather obscure, but it is certainly, I think, a complete but not developed anticipation! One may be excused in not having discovered the fact in a work on Naval Timber." [1]

And three days later, on April 13, 1860, he wrote to J. D. Hooker:[2]

"MY DEAR HOOKER: Questions of priority so often lead to odious quarrels, that I should esteem it a great favor if you would read the enclosed. If you think it proper that I should send it (and of this there can hardly be any question), and if you think it full and ample enough, please alter the date to the day on which you post it, and let that be soon. The case in the *Gardeners' Chronicle* seems a little stronger than in Mr. Matthew's book, for the passages are therein scattered in three places; but it would be mere hair-splitting to notice that. If you object to my letter, please return it; but I do not expect that you will, but I thought that you would not object to run your eye over it."

The statement to which Darwin referred in his letter to Hooker appeared in the *Gardeners' Chronicle* on April 21, 1860 (page 362), and is this:

"I have been much interested by Mr. Patrick Matthew's communication in the number of your paper dated April 7th. *I freely acknowledge*

[1] "The Life and Letters of Charles Darwin," by F. Darwin, 1898. New York: Appleton & Co., p. 95.

[2] *Ibid.*, pp. 95 and 96.

that Mr. Matthew has anticipated by many years the explanation which I have offered of the origin of species, under the name of natural selection. I think that no one will feel surprised that neither I, nor apparently any other naturalist, *had heard of Mr. Matthew's views,* considering how briefly they are given, and that they appeared in the *appendix to a work* on *Naval Timber and Arboriculture.* I can do no more than offer my apologies to Mr. Matthew for my entire ignorance of this publication. If another edition of my work is called for, I will insert to the foregoing effect." [3]

In the Historical Sketch,[4] which he added to the later editions of his book, Darwin gives Matthew credit for the Nature's law of selection in the following words:

"In 1831 Mr. Patrick Matthew published his work on 'Naval Timber and Arboriculture,' in which he gives precisely the same view on the origin of species as that (presently to be alluded to) propounded by Mr. Wallace and myself in the *Linnean Journal,* and as that enlarged in the present volume. Unfortunately, the view was given by Mr. Matthew very briefly, in scattered passages in an appendix to a work on a different subject, so that it remained unnoticed until Mr. Matthew himself drew attention to it in the *Gardeners' Chronicle,* on April 7th, 1860. The differences of Mr. Matthew's view from mine are *not of much importance:* he seems to consider that the world was nearly depopulated at successive periods, and then restocked; and he gives as an alternative, that new forms may be generated 'without the presence of any mould or germ of former aggregates.' I am not sure that I understand some passages; but it seems that he attributes much influence to the direct action of the conditions of life. *He clearly saw, however, the full force of the principle of natural selection.*" [5]

In a letter written by Darwin to J. L. A. de Quatrefages on April 25, 1861, he referred to Patrick Matthew's explanation in a postscript as follows:

"I have lately read M. Naudin's paper, but it does not seem to me to anticipate me, as he does not show how selection could be applied under nature; but an obscure writer on forest trees, in 1830, in Scotland, most expressly and clearly anticipated my views—though he put the case so briefly that no single person ever noticed the scattered passages in his book."

Grant Allen in his biography of Darwin (1888) calls Patrick Matthew the unconscious author of the principle of natural selection which he applied in his book on naval timber to the entire Nature.

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[3] *Ibid.*
[4] "The Origin of Species," 1878, p. xvi. Historical Sketch.
[5] *Ibid.*

Here, then, is a most interesting fact which seems to me of deep significance to foresters. The first Darwinian, who twenty-nine years before Darwin formulated the law of natural selection, was a forester. I shall not attempt here to compare Darwin's and Matthew's views on natural selection. Matthew's book, the full title of which is "Naval Timber and Arboriculture, with Critical Notes on Authors Who Have Recently Treated the Subject of Planting," is accessible in the Congressional Library. The chapter on Nature's Law of Selection is being reprinted in this issue of the PROCEEDINGS OF THE SOCIETY OF AMERICAN FORESTERS, so that every one is able to draw the comparison for himself.

In bringing together this evidence, I am very far indeed from any desire to detract in the least from the great service which Darwin rendered to science. It was Darwin who first gave flesh and blood to the idea of natural selection. It was his wonderful interpretation of all biological facts in the light of natural selection that made the letter the universal law applicable to the entire organic world. Before this accomplishment the claims of all others must sink into obscurity.

My purpose in assembling these records is twofold: First, to restore the memory of one who ploughed the same fields as we do now, the name of a forester whose idea, although it did not perish, slumbered almost unknown for nearly thirty years until another and bigger man brought it to life and general recognition; and, second, to offer an explanation of the reason why a forester above all others should be the one to observe and formulate the law of the struggle for existence as the basis for natural selection and the origin of new species.

My first purpose, I hope, has been accomplished by quoting extracts from Darwin's correspondence. The second still remains.

There is nothing accidental, in my opinion, in the fact that a forester should be the first to observe the struggle for existence and its bearing upon the development of the new varieties, because there is no other plant society in the world which presents a more striking example of the struggle for existence and of natural selection than the forest. Nowhere else, also, can the law of this process be more fully studied.

The regular decrease in the number of trees on a given area with increase in age forms one of the earliest observations of the foresters, who, at a time antedating Darwin, properly gave this process the name of the struggle for existence, the struggle for the necessary growing space. The foresters have discovered the laws governing this process, a process in which almost 95 per cent of all trees that start life in the stand perish, and in the form of yield tables have expressed it quantitatively, have measured and weighed it. They have shown how this struggle for exist-

ence varies with the species, climate, drainage and soil conditions, and age of the stand; that it is more intense, and consequently the differentiation into dominant and suppressed classes occurs earlier, with light-needing species than with shade-enduring ones. In a climate most suitable to the species and on favorable situations this struggle again results in more rapid differentiation into dominant and suppressed trees than when the species grow outside of their optimum range and on poor soils. These are elementary and fundamental facts known to foresters for many years.

The foresters have not only observed these facts, but they have also furnished an explanation for them. The more favorable the conditions of growth the greater is the development of the individual trees; the earlier, therefore, begins the struggle for space and the differentiation into dominant and suppressed, with the subsequent dying out of the latter. They have followed this process throughout the entire life of the stand, have established its various degrees of severity, and have discovered its culmination during the period of the most rapid growth in height. This struggle for space and light is the basis of the forester's operations, as only by utilizing and controlling it is he capable of producing wood of high technical qualities, tall cylindrical poles, free of branches, and wood with uniform annual rings, possessing great elasticity. Without this struggle there is no forest; there is no production of valuable timber save firewood.

The struggle for existence in a forest stand is not confined to individual members of the same age or the same story, but the forest as a whole battles for its existence against the adjoining meadow, swamp, or shrub vegetation; the old trees against the young growth that comes up under them; groups of trees of different species or of different ages against each other. In this struggle the forest accomplishes what no other vegetation does, namely, it actually changes the climate over the area occupied by it and makes it inhospitable for its enemies. The forest creates its own interior environment, to which its own members are completely adapted, but in which other species find either too much or too little light, the humus too scant or too deep or too acid, the temperature too high or too low. Whatever it may be, the forest's competitors are eliminated through the changed environment. To change this environment, however, there must be a close stand; there must be present the struggle for existence among the individual members of the stand. Through interior struggle among its own members the stand secures resistance against invasion by other vegetation. How manifoldly broad and deep, then, is the struggle for existence in the forest.

When we come, now, to natural selection nowhere else is it expressed in such fullness and so strikingly as in the forest. The forest is a natural breeding place in which constantly only the trees best adapted to the climate and the situation are allowed to remain. In the forest only the conquerors in the struggle for existence are the ones which produce seed in abundance. During a seed year the dominant and codominant trees produce seed in large quantities; the intermediate trees, which may properly be called the candidates for suppression, participate but little, and then only in exceptionally good seed years, while the oppressed and suppressed do not bear seed at all. With what rigidity, then, must the natural selection go on in a forest, if we consider, first, what a small percentage of trees in a stand of the same generation come to be conquerors in the struggle for existence; second, the great age reached by trees; third, the numerous generations of trees that have succeeded each other in the same forest; and, fourth, the relatively limited capacity of tree seeds for dissemination. With each generation the forest trees must become more and more delicately adjusted and adapted to the given conditions of growth. The new generation inevitably arises from seed sown by the best developed trees, from those which have withstood the long and intense battle not only against Nature alone, but against Nature in the presence of competitors. Of this possibly only 1 per cent or less will reach maturity and be able to continue the species. No wonder, therefore, that in spite of search for new species all over the world so few forest trees have been successfully introduced into new countries and so little progress has been made with the artificial improvement of them. So perfect is the natural selection in the forest, so fine is the adjustment between the environment and the forest trees that it is almost impossible for man to approach it. I do not mean the introduction of trees for park purposes or breeding new varieties for some other purpose than timber; I have in mind only the establishment of natural forests and the production of timber.

The natural selection forms also the basis of the Forester's operation in selecting trees for seeding purposes, in making regeneration cuttings, in collecting seed for reforestation, and so on.

These few facts are enough to show with what fullness and force the principles advanced by Darwin are expressed in the forest. If agriculture furnished Darwin with many examples of artificial selection upon which he built by analogy his principle of natural selection, the forest, of all plant formations, furnishes the most striking examples and proof of the latter. *As a matter of fact, forestry as an art is nothing else but the*

controlling and regulating of the struggle for existence for the practical ends of man; forestry as a science is nothing else but the study of the laws which govern the struggle for existence.

Is there anything strange, therefore, that it was a forester who first formulated the principles of natural selection? Is there anything strange, also, in the fact that it was also foresters who have laid the foundation for what has come to be known as ecology, which is the logical development of Darwinism? Because of the fact that the forest is the highest expression of plant life, the foresters occupy the strategic position from which they command vistas accessible only with difficulty to other naturalists. In this lies the strength of forestry, its peculiar beauty, and the debt which science owes to it.

PATRICK MATTHEW

NATURE'S LAW OF SELECTION *

BY PATRICK MATTHEW

There is a law universal in Nature tending to render every reproductive being the best possibly suited to its condition that its kind or that organized matter is susceptible of, which appears intended to model the physical and mental or instinctive powers to their highest perfection and to continue them so. This law sustains the lion in his strength, the hare in her swiftness, and the fox in his wiles. As Nature, in all her modifications of life, has a power of increase far beyond what is needed to supply the place of what falls by Time's decay, those individuals who possess not the requisite strength, swiftness, hardihood, or cunning fall prematurely without reproducing—either a prey to their natural devourers, or sinking under disease, generally induced by want of nourishment, their place being occupied by the more perfect of their own kind, who are pressing on the means of subsistence.

Throughout this volume we have felt considerable inconvenience from the adopted dogmatical classification of plants, and have all along been floundering between species and variety, which certainly under culture soften into each other. A particular conformity, each after its own kind when in a state of nature, termed species, no doubt exists to a considerable degree. This conformity has existed during the last forty centuries. Geologists discover a like particular conformity—fossil species—through the deep deposition of each great epoch, but they also discover an almost complete difference to exist between the species or stamp of life of one epoch from that of every other. We are therefore led to admit, either of a repeated miraculous creation or of a power of change, under a change of circumstances, to belong to living, organized matter, or rather to the congeries of inferior life, which appears to form superior. The derangements and changes in organized existence, induced by a change of circumstance from the interference of man, affording us proof of the plastic quality of superior life and the likelihood that circumstances have been very different in the different epochs, though steady in each, tend strongly to heighten the probability of the latter theory.

When we view the immense calcareous and bituminous formations, principally from the waters and atmosphere, and consider the oxidations

* The Gardeners' Chronicle and Agricultural Gazette, April 7, 1860.

and depositions which have taken place, either gradually or during some of the great convulsions, it appears at least probable that the liquid elements containing life have varied considerably at different times in composition and weight; that our atmosphere has contained a much greater proportion of carbonic acid or oxygen, and our waters, aided by excess of carbonic acid and greater heat resulting from greater density of atmosphere, have contained a greater quantity of lime and other mineral solutions. Is the inference, then, unphilosophic that living things which are proved to have a circumstance—suiting power—a very slight change of circumstance by culture inducing a corresponding change of character—may have gradually accommodated themselves to the variations of the elements containing them, and without new creation have presented the diverging changeable phenomena of past and present organized existence?

The destructive liquid currents, before which the hardest mountains have been swept and comminuted into gravel, sand, and mud, which intervened between and divided these epochs, probably extending over the whole surface of the globe and destroying all living things, must have reduced existence so much that an unoccupied field would be formed for new diverging ramifications of life, which from the connected sexual system of vegetables, and the natural instincts of animals to herd and combine with their own kind, would fall into specific groups, these remnants in the course of time moulding and accommodating their being anew to the change of circumstances and to every possible means of subsistence, and the millions of ages of regularity which appear to have followed between the epochs, probably after this accommodation was completed, affording fossil deposit of regular specific character.

There are only two probable ways of change—the above and the still wider deviation from present occurrence—of indestructible or molecular life (which seems to resolve itself into powers of attraction and repulsion under mathematical figure and regulation, bearing a slight systematic similitude to the great aggregations of matter), gradually uniting and developing itself into new circumstance-suited living aggregates, without the presence of any mould or germ of former aggregates; but this scarcely differs from new creation, only it forms a portion of a continued scheme or system.

In endeavoring to trace in the former way the principle of these changes of fashion which have taken place in the domiciles of life, the following questions occur: Do they arise from admixture of species nearly allied, producing intermediate species? Are they the diverging ramifications of the living principle under modification of circumstance?

Or have they resulted from the combined agency of both? Is there only one living principle? Does organized existence, and perhaps all material existence, consist of one Proteus principle of life capable of gradual circumstance-suited modifications and aggregations, without bound under the solvent or motion-giving principle, heat or light? There is more beauty and unity of design in this continual balancing of life to circumstance and greater conformity to those dispositions of nature which are manifest to us than in total destruction and new creation. It is improbable that much of this diversification is owing to commixture of species nearly allied; all change by this appears very limited and confined within the bounds of what is called species. The progeny of the same parents, under great difference of circumstance, might in several generations even become distinct species, incapable of co-reproduction.

The self-regulating adaptive disposition of organized life may in part be traced to the extreme fecundity of Nature, who, as before stated, has in all the varieties of her offspring a prolific power much beyond (in many cases a thousandfold) what is necessary to fill up the vacancies by senile decay. As the field of existence is limited and preoccupied, it is only the hardier, more robust, better suited to circumstance individuals, who are able to struggle forward to maturity, these inhabiting only the situations to which they have superior adaptation and greater power of occupancy than any other kind, the weaker, less circumstance-suited being prematurely destroyed. This principle is in constant action; it regulates the color, the figure, the capacities, and instincts; those individuals of each species whose color and covering are best suited to concealment or protection from enemies, or defense from vicissitude and inclemencies of climate, whose figure is best accommodated to health, strength, defense, and support; whose capacities and instincts can best regulate the physical energies to self-advantage according to circumstance—in such immense waste of primary and youthful life—those only come forward to maturity from the strict ordeal by which Nature tests their adaptation to her standard of perfection and fitness to continue their kind by reproduction.

From the unremitting operation of this law, acting in concert with the tendency which the progeny have to take the more particular qualities of the parents, together with the connected sexual system in vegetables and instinctive limitation to its own kind in animals, a considerable uniformity of figure, color, and character is induced, constituting species, the breed gradually acquiring the very best possible adaptation of these to its condition which it is susceptible of and when alteration of circumstance occurs, thus changing in character to suit these as far as its nature is susceptible of change.

This circumstance-adaptive law, operating upon the slight but continued natural disposition to sport in the progeny (seeding variety), does not perclude the supposed influence which volition or sensation may have over the configuration of the body. To examine into the disposition to sport in the progeny, even when there is only one parent, as in many vegetables, and to investigate how much variation is modified by the mind or nervous sensation of the parents, or of the living thing itself during its progress to maturity—how far it depends upon external circumstance, and how far on the will, irritability, and muscular exertion—is open to examination and experiment. In the first place, we ought to investigate its dependency upon the preceding links of the particular chain of life, variety being often merely types or approximations of former parentage; thence the variation of the family, as well as that of the individual, must be embraced by our experiments.

This continuation of family type, not broken by casual, particular aberration, is mental as well as corporeal, and is exemplified in many of the dispositions or instincts of particular races of men. These innate or continuous ideas or habits seem proportionally greater in the insect tribes, those especially of shorter revolution; and, forming an abiding memory, may resolve much of the enigma of instinct and the foreknowledge which these tribes have of what is necessary to completing their round of life, reducing this to knowledge or impressions and habits acquired by a long experience. This greater continuity of existence, or rather continuity of perceptions and impressions, in insects is highly probable; it is even difficult in some to ascertain the particular stops when each individuality commences, under the different phases of egg, larva, pupa, or if much consciousness of individuality exists. The continuation of reproduction for several generations by the females alone in some of these tribes tends to the probability of the greater continuity of existence and the subdivisions of life by cuttings (even in animal life) at any rate must stagger the advocate of individuality.

Among the millions of specific varieties of living things which occupy the humid portion of the surface of our planet as far back as can be traced, there does not appear, with the exception of man, to have been any particular engrossing race, but a pretty fair balance of powers of occupancy—or rather most wonderful variation of circumstance parallel to the nature of every species, as if circumstance and species had grown up together. There are indeed several races which have threatened ascendancy in some particular regions, but it is man alone from whom any general imminent danger to the existence of his brethren is to be dreaded.

As far back as history reaches man had already had considerable influence and had made encroachments upon his fellow-denizens, probably occasioning the destruction of many species and the production and continuation of a number of varieties or even species which he found more suited to supply his wants, but which from the infirmity of their condition—not having undergone selection by the law of nature, of which we have spoken—cannot maintain their ground without its culture and protection.

It is, however, only in the present age that man has begun to reap the fruits of his tedious education and has proven how much "knowledge is power." He has now acquired a dominion over the material world and a consequent power of increase, so as to render it probable that the whole surface of the earth may soon be overrun by this engrossing anomaly, to the annihilation of every wonderful and beautiful variety of animated existence which does not administer to his wants principally as laboratories of preparation to befit cruder elemental matter for assimilation by his organs.

Much of the luxuriance and size of timber depending upon the particular variety of the species, upon the treatment of the seed before sowing, and upon the treatment of the young plant, and as this fundamental subject is neither much attended to nor generally understood, we shall take it up *ab initio.*

The consequences are now being developed of our deplorable ignorance of or inattention to one of the most evident traits of natural history, that vegetables as well as animals are generally liable to an almost unlimited diversification, regulated by climate, soil, nourishment, and new commixture of already formed varieties. In those with which man is most intimate, and where his agency in throwing them from their natural locality and dispositions has brought out this power of diversification in stronger shades, it has been forced upon his notice, as in man himself, in the dog, horse, cow, sheep, poultry; in the apple, pear, plum, gooseberry, potato, pea, which sport in infinite varieties, differing considerably in size, color, taste, firmness of texture, period of growth—almost in every recognizable quality. In all these kinds man is influential in preventing deterioration by careful selection of the largest or most valuable as breeders; but in timber trees the opposite course has been pursued. The large growing varieties being so long of coming to produce seed that many plantations are cut down before they reach this maturity; the small growing and weakly varieties, known by early and extreme seeding, have been continually selected as reproductive stock

from the ease and conveniency with which their seed could be procured, and the husks of several kinds of these invariably kiln-dried in order that the seeds might be more easily extracted. May we, then, wonder that our plantations are occupied by a sickly, short-lived, puny race, incapable of supporting existence in situations where their own kind had formerly flourished, particularly evinced in the genus Pinus; more particularly in the species Scots fir, so much inferior to those of Nature's own rearing, where only the stronger, more hardy, soil-suited varieties can struggle forward to maturity and reproduction?

We say that the rural economist should pay as much regard to the breed or particular variety of his forest trees as he does to that of his live stock of horses, cows, and sheep; that nurserymen should attest the variety of their timber plants, sowing no seeds but those gathered from the largest, most healthy, and luxuriant growing trees; abstaining from the seed of the prematurely productive, and also from that of the very aged and overmature, as they from animal analogy may be expected to give an infirm progeny, subject to premature decay.

(See "Naval Timber and Arboriculture," pp. 364, 365, 381-388; also pp. 106-108. Patrick Matthew, Gourdee Hill, Errol, N. B., March 7.)

IS EUCALYPTUS SUITABLE FOR LUMBER?

Results of Experiments Conducted at Berkeley, California, in the Forest Service Humidity-Regulated Dry Kiln During the Winter and Spring of 1911–1912 and the Winter of 1912–1913.

BY HARRY D. TIEMANN

Contributed

INTRODUCTION

The object of this undertaking was to determine first of all whether the blue gum growing in California could be successfully dried on a practicable basis for use as lumber, and if not, whether any other species of eucalyptus growing in the State would be more suitable.

As the experiments have been fully discussed in an article submitted for publication, I will confine myself here to a very brief review of the subject and to a summary of the results and conclusions reached, with a discussion of some of the most interesting facts brought out by the study.

For the purpose of carrying on these experiments the humidity-regulated dry kiln invented by the writer was used. A wooden kiln was built by the coöperator, F. C. Havens, in a large grove of eucalyptus situated on the hill northeast of Berkeley, according to design and specifications furnished by the Forest Service. The drying-room was approximately 8 feet wide by 9 feet high above the rails by 36 feet long, and was divided into three sections by canvas curtains. The end doors were wood. On the east side was a passageway, M, figure 1, for inspection purposes. This was entirely shut off from the kiln and had six doors opening into the drying chamber. On either side were the spray chambers B. The regulating apparatus and pump for the water sprays was in a room at the north end beneath the platform. The sections were numbered, beginning at the north end, I, II, and III. High-pressure steam was used day and night, the pressure in the kiln being reduced to any desired amount by a reducing valve. The temperature of the kiln was controlled also by a thermostat acting on the steam supply.

By this kiln it was possible to obtain any humidity from dry to nearly saturation and any temperature from 120° F. to the boiling point.

A large steaming cylinder, capable of holding 20 pounds pressure, and a boiling tank, in which entire logs could be boiled for any desired length of time, were included in the equipment.

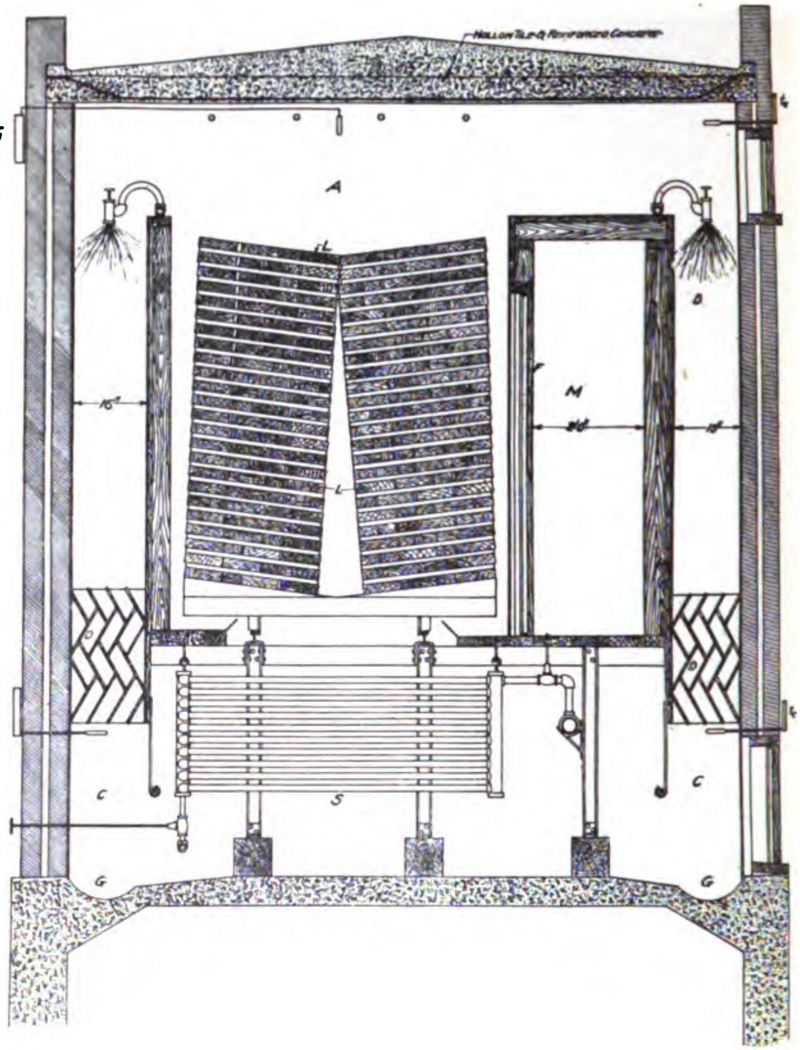


FIG. 1.—*Diagram of the Dry Kiln Used in These Experiments*
(The Tiemann Humidity-Regulated Dry Kiln)

The grove on the side of which the kiln was built was about 34 years old and consisted of blue gum trees, with a few manna gums. Part of the material was obtained from this grove and part from a grove of about the same age at Piedmont; also one exceptionally large specimen of blue gum from the roadside two or three miles east of Piedmont (this tree was numbered 110). The quality of the timber was equal to any in the

State, with the exception of the San José gum, which will be described later.

THE FIRST WINTER'S EXPERIMENTS

Run No. 1—Fresh green lumber was used in the first runs. After a few preliminary drying experiments, it was found that to use the average run of material was absolutely futile, since the stuff was already in a hopeless condition due to checking and warping before entering into the kiln. It was therefore decided to place only carefully selected inch boards in the kiln and to use as much quarter-sawed material as possible.

Accordingly, two logs were obtained from a thrifty tree 2½ feet in diameter and two logs from a tree about 2 feet in diameter, both from the Piedmont grove, and sawed into inch boards. Three treatments were used in the first run: (1) Preliminary steaming at two or three pounds pressure for 3½ hours and plunging directly into hot water; (2) preliminary heating in water 24 hours, and (3) placing the green boards directly into the kiln without previous treatment. The temperature at the beginning of the operation was about 130° F., with 70 to 80 per cent humidity. The original moisture in these boards varied from 87 to 98 per cent. No free steam was used in the air at any time. The circulation as measured by an anemometer amounted to about 200 cubic feet per minute for each foot length of kiln. The humidity was gradually decreased and the temperature raised until the conditions were 170° F. and 63 per cent humidity. The wood dried in 28 days. Moisture discs cut from 13 boards showed from 6 to 12 per cent moisture.

Practically no checking or honeycombing occurred in any of the quarter-sawed boards and only a little in the slab-cut boards, but without exception all had greatly shrunken, chiefly circumferentially, and all quarter-sawed boards were deeply corrugated like a washboard, due to unequal shrinkage of consecutive rings. With the exception of the quarter-sawed boards the wood warped very badly. Slightly more than half the material was practically good for nothing; the rest could be planed to half-inch boards. There was no appreciable difference between the three treatments.

Run No. 2—In the second run an immense tree 13 feet in circumference, growing along the roadside several miles from Piedmont, was selected as being the best tree obtainable. Its age was between 36 and 40 years. Two 10-foot logs, numbered 110 and 111, respectively, were sawed into 1⅛-inch boards, and some ¼-inch veneer. The latter was put aside to air-dry between sheets of corrugated iron, and some of it dried in Run No. 4. This wood contained 90 per cent moisture when placed in the

kiln. Boards from two other blue gum trees and one manna gum were included in this run. A portion of each was steamed two hours at about three pounds and another portion for 3½ hours; both lots were doused directly into hot water. These boards were placed in Sections II and III. Drying began at a temperature of about 135° in Section II and 143° in Section III and a humidity of 82 per cent.

The temperatures were finally raised to about 160° in Section II and 170° in Section III, with humidities, respectively, of 40 and 42 per cent. The truck from Section II was removed in 27 days and the other in 25 days.

In the remaining section (No. I) was placed a miscellaneous assortment of boards, including: Manna gum (*Eucalyptus viminalis*); several boards of red ironbark (*Eucalyptus sideroxylon*); some boards from blue gum trees which had been dead for several years before they were felled and blue gum boards which had soaked in hot water (between 150° F. and 212° F.) for 22 days. The manna gum contained 96 per cent moisture. Drying was begun at about 125° temperature and 80 per cent humidity. The temperature was raised to 160° finally and humidity reduced to 38 per cent. They dried in 24 days.

The material from the large blue gum tree dried with no honeycombing and practically no checking except through the centers of the boards, which were cut through the center of the log. The shrinkage, however, was great, especially toward the center of the tree, and there was a great deal of warping of a conchoidal nature. This peculiar warping was produced by a beautiful wavy grain which the entire tree possessed.

The moisture was reduced to about 4 per cent in the wood in Section III, 6 to 9 per cent in Section II, and 4 to 12 per cent in Section I. In regard to the treatments, as before there appeared to be but little difference. The manna gum was about equal to the poorest of the blue gum except the *sapwood,* and this alone dried as well as a piece of ash. The lumber previously soaked 22 days in hot water showed no marked advantage over similar pieces dried in the previous experiment.

The red ironbark dried in a totally different manner; it did not shrink excessively, warped less, and did not corrugate or honeycomb. It much resembled black cherrywood.

By way of comparison a board of blue gum was obtained from T. J. Gillespie at San José and placed in the kiln with the rest. Mr. Gillespie is a eucalyptus manufacturer and claims that he has a distinct species of blue gum. This board dried very much better in every respect than the other blue gum, and would appear to substantiate his claims. However, it has been impossible to determine any botanical or morphological differ-

ence between Mr. Gillespie's trees, which he terms "San José blue gums," and the ordinary blue gum trees, although the wood is unquestionably of better quality than that of even the best ordinary blue gums.

Numerous other experiments were carried on, such as steaming and boiling the whole logs before sawing them, in an attempt to remove the internal stresses. Three days' steaming followed by cooling under water succeeded in eliminating the internal stress, but so softened up the fibers that the toughness of the wood was destroyed and the wood checked in drying in a multitude of very small checks.

Shrinkage experiments were made upon small measured pieces, the results of which are given near the end of this article under "Summary of Results."

THE SECOND WINTER'S EXPERIMENTS

Run No. 3—During the winter of 1912 and 1913 two other runs were made; the first one (Run No. 3) was made with some of the boards from last season, which had been purposely set aside for preliminary air-drying, and the second one (No. 4) upon several species of eucalyptus other than blue gum and upon several species of acacia. The lumber in Run No. 3 was dried in 13 days, and the results indicated that there was less shrinkage and corrugating in material which had been previously air-dried than in material placed in the kiln while green.

Run No. 4—A careful study of the subject of eucalyptus lumber developed the conclusion that certain other species which can be grown in California are much better for lumber than the blue gum. These appeared to be gomphocephala, corynocalyx, and resinifera. Accordingly, an effort was made to obtain mature trees of these species, but after much search only corynocalyx of fair size was obtained. Some very small specimens of resinifera were procured, but they were too small to determine how wood from mature trees would behave. They were sawed up, however, into boards, and some equally small blue gums of about the same age and one manna gum were placed with them by way of comparison.

All this material was mixed promiscuously and placed upon one truck in the middle section (No. II).

A miscellaneous assortment of 1-inch boards of eucalyptus, including viminalis, obliqua, rostrata, and sieberiana, together with the acacia, were piled upon another truck and run into the end section (No. III).

In Section I were placed several sheets of ¼-inch veneer, about 34 inches wide, from the large tree (No. 110), which had been air-drying between sheets of corrugated iron about nine months; also a splendid board of "San José" gum procured from Mr. Gillespie. This board was

freshly sawed, about 20 inches wide, 12 feet long, and in perfect condition.

The truck in Section II remained in 22 days and the one in Section III 20 days.

Results from Section II—The results showed that corynocalyx dried in an excellent manner without corrugating. Resinifera, however, had shrunken badly and did not appear much better than the small blue gum, but it is not possible to state from this how the lumber from large mature trees would act. Moreover, the wood was of a finer and more uniform texture than the blue gum.

A comparison of the manner in which resinfera, globulus, corynocalyx, and two acacias dry is shown in Plate I.

While corynocalyx dries very well indeed, it is not a large tree and is apt to grow crooked. Resinifera, on the other hand, is the straightest growing of the species, but in California it is only about two-thirds as rapid as the blue gum and does not appear to be as hardy.

In order to find out whether the conclusions arrived at as to the growing qualities of *Eucalyptus resinifera* were borne out in California, letters were written to as many persons as were known to be familiar with this species in California and to one in the Sandwich Islands. The replies are as follows:

Present Opinions Regarding Eucalyptus Resinifera

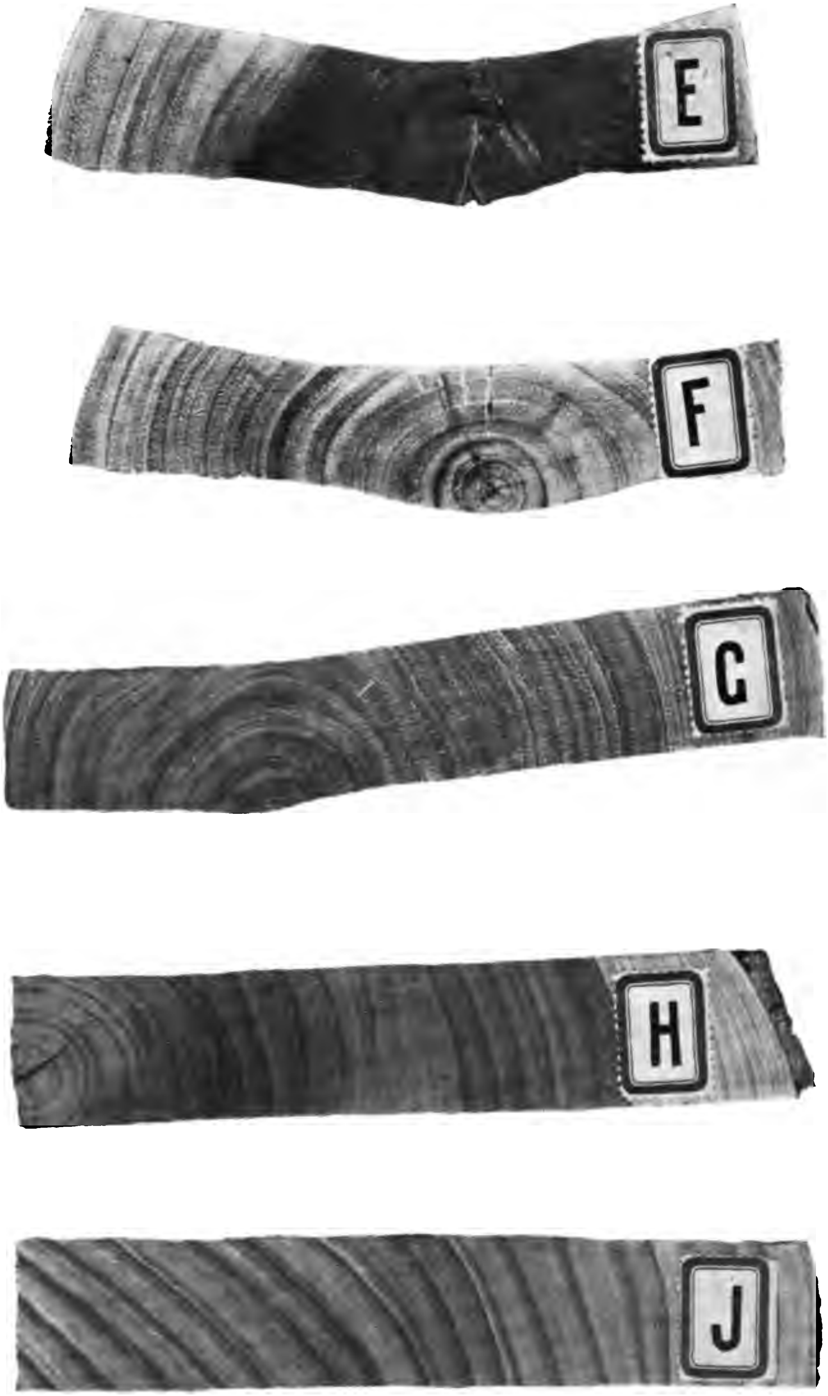
Louis Margolin writes, under date of December 16, 1912, regarding the growth of this species in the Hawaiian Islands:

"At the lower elevations on the Hawaiian Islands (below the 1,000-foot contour) *E. resinifera* is considered a more desirable tree for planting than *E. globulus,* both because of its more rapid growth and because of its better qualities. At Haiku Hill, on the Island of Maui, at elevations between 500 and 800 feet, a nine-year-old plantation of *E. resinifera* yielded 30 cords of wood to the acre. Sprouts two years and eight months old ran about 5 inches in diameter breast high, and were from 30 to 40 feet high. *E. globulus* sprouts in the same plantation and at the same age average only about 3 inches d. b. h. *E. resinifera* posts were said to last in the ground much longer than *E. globulus* posts of the same age. At the higher elevations *E. globulus* is the more desirable species, *E. resinifera* not doing well at elevations of over 3,000 feet."

W. A. Hayne, San Luis Obispo, California, writes December 4, 1912:

"The resinifera is the most beautiful of *all* the woods. I have a polished sample. It closely resembles rosewood. Cabinet-makers in San Francisco *pronounced* it rosewood. The resinifera grows in this particular locality as fast as the blue gum. I am sorry I did not plant more of them." (He has four trees two years old and about 18 feet high.)

PLATE I



COMPARISON OF VARIOUS SPECIES

E. *Eucalyptus resinifera* G. *Eucalyptus corynocalyx*
F. *Eucalyptus globulus* H. and J. *Acacia*

Louis A. Vucovich, Hanford, California, writes December 2, 1912:

"We have in our grove a few trees of *E. resinifera;* they are five years old; they compare well with other varieties for growth in this part of the country."

Theodore Payne, nurseryman, Los Angeles, writes on December 13:

"It is generally considered to be adapted to warm, moist sections near the coast. It stands about the same frost or a little more than globulus. It is, however, slower growing. It furnishes splendid lumber and the tree grows very straight."

William H. Brintnall, Guadalupe, planted about 20 acres to resinifera a year ago last April.

In Plate II, figures 1 and 2, are shown two groves, one resinifera and the other corynocalyx, of almost exactly the same age, namely, 10 years, and growing adjacent to each other in the relative positions as shown on the page. These groves are on the Experiment Station at Santa Monica. The difference in form of growth is striking.

Results from Section III—A most striking and significant result was the comparison between the acacia wood and the miscellaneous species of eucalyptus from Section III. Without exception the eucalyptus was badly shrunken and warped, while the acacia, promiscuously mixed with the eucalyptus, with the exception of a single tree, came out in splendid condition, showing no detrimental shrinkage, warping, or checking and no corrugating whatever. This comparison was so positive as to leave no question that the eucalyptus in general is a greatly inferior wood on account of the way in which it dries.

Results from Section I—The ¼-inch veneer was dried for 13 days and came out in almost perfect condition. There was some shrinkage and conchoidal surface effect, but not enough to be detrimental. The corrugated iron held the sheets flat so they did not warp seriously. The large sheets which passed near the center of the logs cracked along the pith line; otherwise there was no checking.

The San José board came from the kiln in perfect condition. It did not warp, check, or even corrugate, and, according to information, as late as July 8 was still in the same condition.

Its shrinkage in thickness was measured at eight points. This showed the irregularities characteristic of the species, but even the maximum amount was considerably less than that of the ordinary blue gum. The following are the shrinkage percentages of the green dimensions. They are given in consecutive order, following around the edges of the board

and measured about 2 inches from the edge, beginning on the center line near one end:

a. 5.6 per cent on center line near one end.
e. 2.2 per cent
d. 2.8 per cent } along one edge.
c. 2.7 per cent
b. 6.1 per cent on center line near opposite end.
f. 9.4 per cent
g. 7.3 per cent } along opposite edge.
h. 3.7 per cent

The moisture reduction was from 47.5 to 11.4 per cent. Compare this shrinkage with that given in the table on page 312.

SHRINKAGE

A number of small specimens were cut 6 inches long, eight pieces being 9 inches wide and two 8 inches. These were green when prepared and were boiled several days and then placed in the kiln with Run No. 2 and the widths measured periodically. Shrinkage began at 90 per cent moisture and continued at a fairly uniform rate, so that the path, plotting actual width against moisture per cent, is approximately a straight line.

Two remarkable facts are apparent; first, that shrinkage begins at as high as 90 per cent moisture content in some cases instead of at 25 or 30 per cent, as in most woods, and, second, the *rate* of shrinkage is not greater than in the case of redwood.

The total shrinkage from green to oven-dry in per cent of the dry dimension is given in the following table:

		Per cent
No. 1.	Redwood, rings diagonal	5.1
No. 6.	San José gum *radial* cut from outer portion of board 3 feet wide	6.6
No. 3.	Piedmont blue gum *radial* cut from outer portion of very wide board	14.0
No. 9.	Piedmont blue gum *radial cut* from inner portion, pith on one edge	16.2
No. 5.	San José gum *radial* inner portion of same board as No. 6	17.6
No. 4.	San José gum *tangential* cut	17.8
No. 8.	Piedmont blue gum *tangential* cut	30.2
No. 10.	Piedmont blue gum *tangential* cut (another specimen)	30.2
No. 2.	Piedmont blue gum diagonal rings	23.0
No. 7.	Steamed piece of Piedmont blue gum *radial*	16.6

A similar series of shrinkage measurements were made in Run No. 4 on the several species of eucalyptus and acacia.

PLATE II

FIG. 1.—TEN-YEAR-OLD GROVE OF EUCALYPTUS CORYNOCALYX AT SANTA MONICA

FIG. 2.—TEN-YEAR-OLD GROVE OF EUCALYPTUS RESINIFERA AT SANTA MONICA

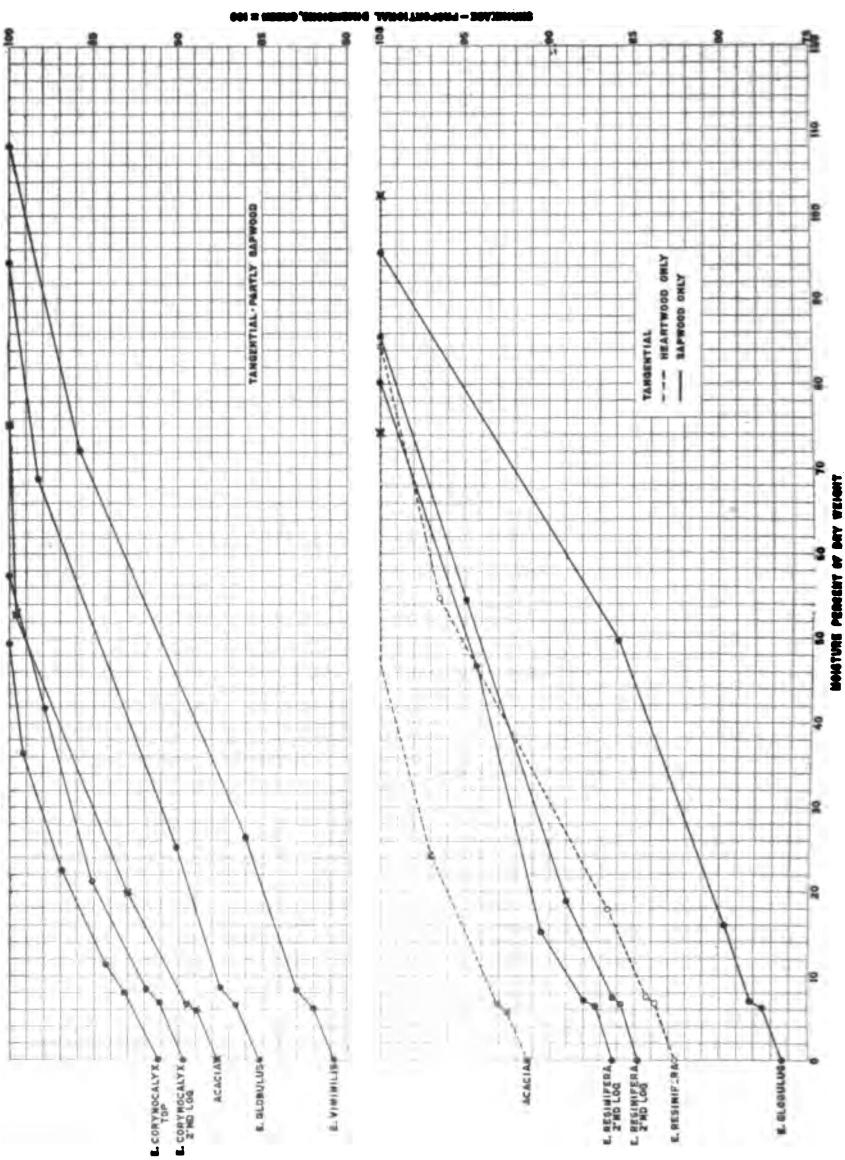


FIG. 2.—*Shrinkage Curves*

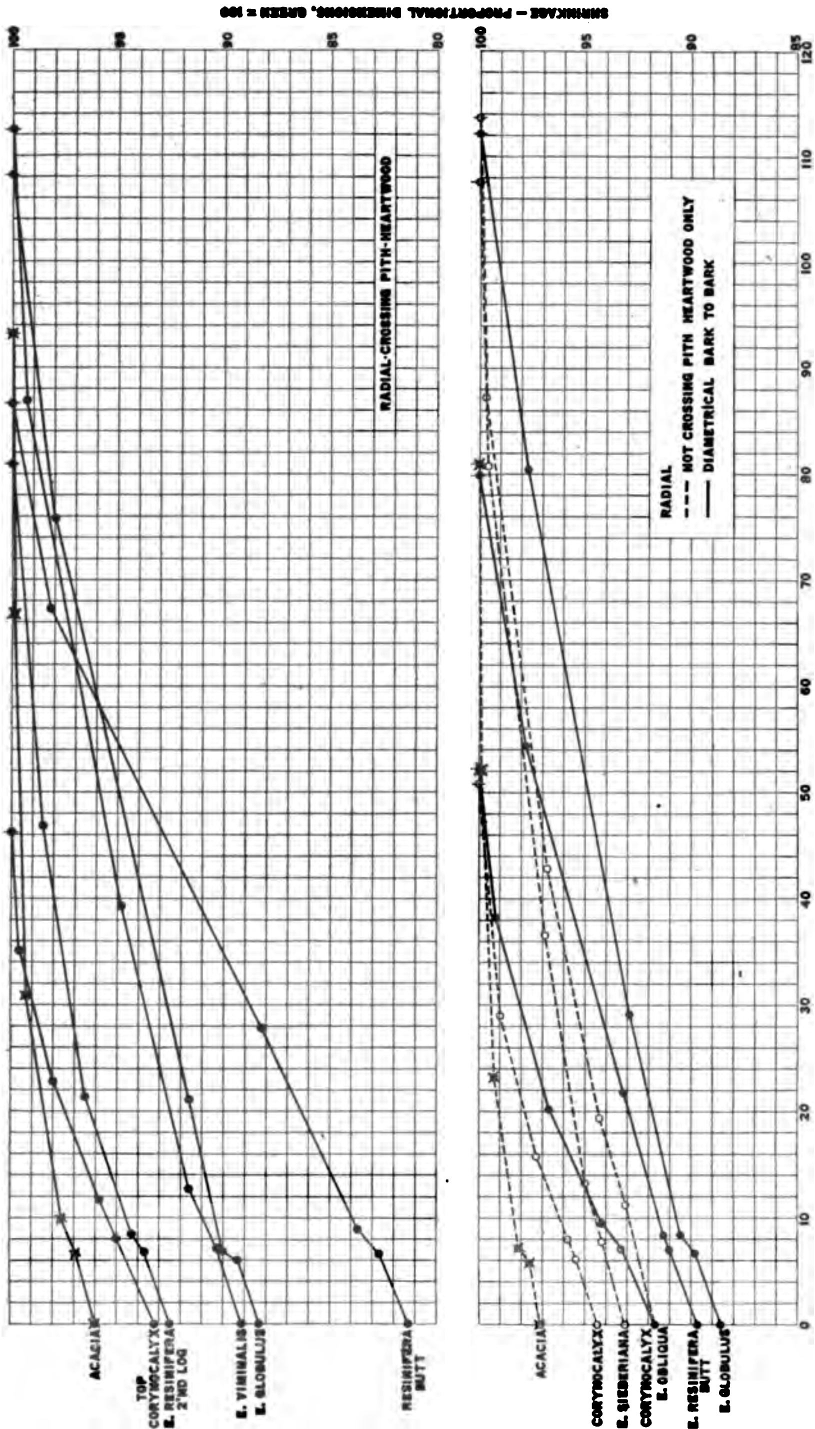


FIG. 3.—*Shrinkage Curves*

Total Shrinkage in Linear Dimensions, from Green to Oven-dry.

No. of log.	Species.	Position in tree.	Largest diameter of log.	Original moisture.	Original width of piece.	Linear shrinkage. Green.	Linear shrinkage. Dry.	How measured.
			Inches.	*Per cent.*	*Inches.*	*Per cent.*	*Per cent.*	
224	E. globulus......	Butt log...........	6½	108	3.172	11.7	13.2	HR = Diametrical, crossing pith; heartwood only.
222	E. viminalis.....	Butt log...........	9	112	4.485	10.9	12.2	
213	E. resinifera....	Butt log...........	8	87	2.780	18.7	23.0	
214	E. resinifera....	Second log.........	5½	81	4.376	7.5	8.1	
221	E. corynocalyx..	Third log..........	....	46	5.705	6.8	7.2	
17b	Acacia.........	....	24	93	6.141	3.96	4.12	
219	E. corynocalyx..	Butt log...........	12	51	4.179	5.6	6.0	½ HR = Radial, not crossing pith; heartwood only.
205	E. obliqua.......	....	12	114	3.952	8.3	9.1	
204	E. sieberiana....	....	18	108	6.032	6.9	7.4	
15	Acacia.........	....	14	81	3.759	2.9	3.0	
224	E. globulus......	Butt log...........	6½	112	5.085	11.4	12.9	R = Diametrical, from bark to bark.
216	E. resinifera....	Butt log...........	8	80	5.140	10.3	11.5	
221	E. corynocalyx..	Third log..........	....	52	5.664	8.3	9.1	
223	E. globulus......	Butt log...........	8	94	4.553	14.8	17.3	T = Tangential, both heart and sapwood.
222	E. viminalis.....	Butt log...........	9	108	3.365	19.2	23.8	
220	E. corynocalyx..	Second log.........	....	57	5.128	10.3	11.5	
221	E. corynocalyx..	Third log..........	....	49	4.994	8.8	9.6	
17a	Acacia.........	....	24	75	5.645	12.3	14.0	
213	E. resinifera....	Butt log...........	8	84	3.357	17.4	21.0	HT = Tangential, heartwood only.
17	Acacia.........	....	24	102	6.264	8.7	9.5	
223	E. globulus......	Butt log...........	8	96	3.365	23.6	30.8	ST = Tangential, sapwood only.
214	E. resinifera....	Second log.........	5½	80	3.323	13.7	15.9	
217	E. resinifera....	Second log.........	5¾	86	3.550	15.2	18.0	

The specimens marked R and HR, which included the pith, as a rule checked open from the pith outwardly to the two opposite surfaces, due to the greater tangential shrinkage. This did not invalidate the measurements, however, as they were taken diametrically across the pith. The table shows the superiority of *Eucalyptus corynocalyx* over the other species of eucalyptus, and the decided superiority of the acacia over them all as to minimum shrinkage.

This is also clearly shown in the curves. Another noteworthy fact is brought out by the curves. Most woods do not begin to shrink upon losing moisture until a certain point is reached, known as the "fiber saturation point," which occurs at a moisture content varying from 30 to 20 per cent according to species of wood. Eucalyptus, particularly the blue gum, appears to be a striking exception to this, as it begins to shrink upon the slightest loss of moisture, even at 90 per cent or more. This characteristic difference is seen in the shrinkage curves by comparing the acacia with the eucalypts. The curves for the acacia remain very nearly on the 100 line as drying takes place until about 30 per cent moisture in the radial and 50 per cent in the tangential is reached, whereas the curves for the eucalypts begin to fall off immediately. *Eucalyptus corynocalyx,* however, appears to act more like the acacia, but as its moisture content does not run above approximately 50 per cent its condition beyond this point is not manifest.

SUMMARY OF RESULTS

1. The blue gum wood in trees of the average size under 40 years of age and less than about 30 inches in diameter contains internal stresses in the living tree, which cause the logs to check on the ends as soon as the tree is felled and the boards or sticks to warp outwardly on the saw. This is a great defect. In trees larger than about 30 inches and older than 40 years these strains are less pronounced and not a serious factor.

2. The wood of the blue gum begins to shrink immediately from the green condition, even when at 70 to 90 per cent moisture content, instead of at 30 or 25 per cent as in other species of hardwoods. This is a serious defect, causing continual checking from the time the trees are felled. The effect is aggravated by the internal stresses in the wood.

3. The shrinkage is excessive, particularly in the younger trees and in the inner portion of the older trees. It is from five to six times as great as in conifers.

4. Shrinkage is exceedingly irregular, varying greatly in amount not only in different portions of the same log, but in the consecutive layers of the concentric rings. This produces internal strains, honeycombing, warping, and the peculiar corrugating on the surface of radially cut boards.

5. Shrinkage is much greater tangentially than radially, being at least twice as great in the one as in the other. This produces internal stress, severe checking, and a certain kind of warping.

6. Sapwood shrinks much less than heartwood. This is particularly true with manna gum.

7. The above statements apply with even greater force to manna gum and in fact to most species of eucalyptus.

Results of Attempts to Overcome these Difficulties in Drying

8. Internal stresses can be removed by steaming the logs several days and immersing them under water, but the tenacity and quality of the wood is destroyed thereby.

9. The green wood cannot be dried with any success at high temperature, owing to the fact that it becomes very soft and plastic while moist and the cells collapse in drying, causing even greater shrinkage and checking.

10. If the boards can be obtained free from checks while green, they can be dried in my humidity-regulated kiln without checking or honeycombing, but the shrinkage and warping cannot be successfully eliminated.

11. Quarter-sawed boards on account of geometrical relations of the stresses will dry flat without warping, but they corrugate greatly on the surface, so that not more than one-half inch lumber can be finished out of inch stock.

Slab-cut boards are bound to either cup or check on the concave side.

12. The shrinkage is greater the higher the temperature of drying while the lumber is moist; when it is fairly dry, temperature as high as 170° F. is not harmful. Therefore, the best results are obtained by beginning the drying at a very low temperature, preferably less than 120° F., or else allow the lumber to air-dry for about eight months before placing in the kiln. Unless thoroughly protected from sun and wind, however, the lumber will check badly, even in air-drying.

13. Preliminary steaming or boiling or soaking in hot water is not beneficial and may be harmful.

14. Lumber from the outer portion of large trees over 40 years of age and above about 30 inches in diameter is greatly superior in every respect to that from smaller and younger trees. There is, moreover, a great variation in the individual trees, even of the same size and age and growing side by side.

15. The superiority of lumber from the so-called "San José blue gum" trees appears to be due rather to a selection of individual specimens of peculiar quality than to an inherent difference in variety, but the latter

question is not fully decided. In either case it would seem desirable to plant the seed from these selected trees rather than from the ordinary blue gum, with the possibility that they might reproduce wood of a similar quality.

16. Veneer and plates up to ¼ inch in thickness can be dried flat without checking, but the tendency to shrink, swell, and warp remains.

17. Girdling standing trees and sawing the lumber after several years when the trunk has become partially dry reduces the shrinkage somewhat, but it does not remove the internal stresses nor does it overcome the checking and honeycombing in the log. It would appear better to saw the lumber green and allow it to dry slowly in the air, although it checks very badly in air-drying.

18. Study of literature indicates certain species which will grow in California as much more suitable for lumber than blue gum. These are red mahogany, *Eucalyptus resinifera;* tooart, *Eucalyptus gomphocephala,* and sugar gum, *Eucalyptus corynocalyx.* Experiment proved that the conclusion regarding sugar gum was correct. It dried nicely without checking and with insignificant, if any, corrugating. It dried almost as well as acacia. It was not possible to secure a specimen of tooart for the purpose and only very small 10-year-old trees of *Eucalyptus resinifera.* The results were inconclusive on this account, although the pink heartwood appeared of finer, more uniform texture than the blue gum. The sapwood of resinifera dried perfectly. Unfortunately, the corynocalyx is a rather small tree and grows crooked. Gomphocephala is also a small tree and its adaptability to California conditions is not well known, as so far as known there are only three trees in the State—at the Santa Monica Experiment Station. Resinifera is a remarkably fine-shaped tree from the lumber standpoint and seems to do well in the State, but it grows slower than globulus and apparently is not so hardy. The oldest trees in the State, so far as known, are in the 10-year-old grove at Santa Monica, from which the three specimen trees were taken. The red ironbark, *Eucalyptus sideroxylon,* is an excellent wood, as shown by the drying experiments, but the trees appear to grow either crooked or rotten-hearted.

The most promising tree from a lumber standpoint is the red mahogany, *Eucalyptus resinifera;* but the quality of its wood in California from mature-sized trees cannot yet be determined, as none have been discovered.

19. Compared directly with acacia in our experiments, eucalyptus, with the exception of the species mentioned in the last paragraph and certain selected large trees growing at San José, termed "San José gum," is very decidedly an inferior wood on account of its drying qualities, and stands very distinctly apart from the acacia or other good hardwood.

CONCLUSIONS

The answer to the two questions is conclusive from these experiments. A single statement, however, cannot be made, since the phrase "suitable for lumber" requires definition. If it applies to boards or larger sizes the proportion of good material which can be obtained from even the best groves in the State is so small, less than one-tenth of 1 per cent, that there can be no profit in the production. If it refers to small stock, such as insulator pins, narrow flooring less than 2 inches wide in short lengths, tool handles, and such articles which can be cut out from between the checks and warped portions, probably one-quarter to one-third of the standing lumber can be utilized.

In the case of trees more than 40 years old and over 30 inches in diameter which have grown in the open or along roadsides, the proportion of each class is much greater; perhaps one-third to one-half of the lumber from these trees could be utilized for small stock and possibly 5 or 10 per cent would dry into a fair quality of boards or planks. It is only an occasional tree, however, even of the large sizes, which will yield lumber of *good* quality. The best is from trees, said to be 45 years old, growing at San José, discovered by Mr. T. J. Gillespie. Probably there are not now standing more than a dozen of these trees.

Secondly, there are several other species of eucalyptus which yield a much better kind of lumber than the blue gum. The best of these which have been proved in the experiments are *Eucalyptus corynocalyx* and *Eucalyptus sideroxylon;* but *Eucalyptus gomphocephala,* according to reports from other countries, should prove good also, but it is small and its adaptability to California climate has not been well tried out. *Eucalyptus corynocalyx,* however, grows crooked and is a small tree, while *Eucalyptus sideroxylon* grows rotten-hearted and with imperfections, according to our experience and the reports of others. The red mahogany, *Eucalyptus resinifera,* seems altogether the most promising for a lumber tree, although the wood of the immature 10-year-old trees dried but little better than the blue gum. Still larger trees would no doubt act much better. *Eucalyptus resinfera,* however, is not as hardy as the blue gum and is slower growing. Red gum, manna gum, and stringy bark (*Eucalyptus obliqua*) are worse than the blue gum, and *Eucalyptus siberiana,* mountain ash, is little if any better.

The conclusion of the whole matter is that to the best of our present knowledge there can be little or no profit in growing any species of eucalyptus for lumber purposes alone.

COÖRDINATION OF GROWTH STUDIES, RECONNAISSANCE, AND REGULATION OF YIELD ON NATIONAL FORESTS

BY HERMAN H. CHAPMAN

Contributed

Until recently the annual cut permitted upon National Forests has been determined by Von Mantel's method, based solely on the present nature of the merchantable stand and a somewhat arbitrary rotation. A few attempts have been made lately to base the cut upon the increment of the forest by use of the Austrian formula. At the same time there has come a general awakening to the fact that our knowledge of the actual increment of virgin forests is conspicuously lacking. Without this knowledge systematic regulation of yield must remain on crude and wholly unsatisfactory foundations.

The question cannot be dodged by quoting the generality that in virgin forests growth equals decay. This holds good only for very large areas and periods, while over most single forests and portions of forests the timber resolves itself into age groups, which are increasing, stagnating, or retrograding according to their age. The forester must know the composition of his forest by age classes, and measure both increment and loss and the effect which utilization will have in preventing the loss and stimulating the increment. Present volume alone as a basis serves only to regulate yield for the immediate future. Upon growth depends the true regulation and maintenance of sustained output. These growth studies should have for their object the measurement of the actual increment on the entire forest and not merely on sample plots. On account of poor stocking and damage this total increment will always be lower than the yield obtained on well-stocked plots. For the problem of regulation it is not the "normal" yields, but the actual total increment that must be found. There is but one way by which this data can be obtained, and that is through the coördination of growth measurements with the reconnaissance of the entire area.

The neglect of this truth has resulted in large areas being covered by reconnaissance without obtaining the proper basis for determining yields, when the needed facts could have been recorded during the work without increased expense.

Recognition of this error now may result in committing one almost as bad, namely, the attempt to collect actual growth and yield data as an

integral part of timber reconnaissance. It is probably impossible to do this satisfactorily, even where forests are even aged, and is wholly out of the question in forests of mixed-age classes. What is needed is a separate study of growth, combined with a definite plan for applying the results of this growth study to the forest by means of additional data, easily obtained in reconnaissance. Growth studies and reconnaissance cannot be satisfactorily combined in one operation.

A necessary part of reconnaissance data is the recognition of broad types and quality of site. The first of these distinctions is generally accepted. Quality distinctions are more frequently neglected. They should be broad enough to be distinguishable by field parties, and the classification of "forties" by quality should be insisted upon as a primary factor in determining growth and yield per acre by any method.

Our forests may be grouped into three classes, based on the distribution of ages, namely:

Group I. Even aged.
Group II. Many aged by groups.
Group III. All aged, or selection.

Increment in Group I forests, as lodgepole pine, Douglas fir, and white pine, has been studied on plots whose yield and average age is found on the basis of area. The difficulty in this group comes in applying the yields thus obtained to the whole forest or type. The percentage of reduction from the yield table, always necessary in any forest, depends here very largely on the standard of the yield table itself. When strenuous efforts have been made to secure "normal" yields, the results are found to be so far above even the average best that all stands must be heavily reduced from the standard yields. It is in this class of forests in one District that the opposite extreme has been advocated, of accepting the reconnaissance estimates as yields, by requiring the determination of age only in addition to the volumes. This method may approximately accomplish the one result aimed at, which is to secure average yield for the total area by age classes; but the chief defects of the plan are the hasty and inaccurate determination of age and separation of age classes and the purely empirical yields obtained by including all degrees of stocking and much waste or blank area. The yield table will apply only to the areas measured and the work must be repeated on other tracts. In other words, the advantages of a standard yield table serviceable over wide areas and for various problems of management are not secured.

A possible compromise between these extremes is to extend the basis for the so-called "normal" yield table without entirely departing from it

in principle. Plots of larger size are chosen, fairly well stocked, but with no attempt to secure full density. Blanks caused by burns and by lack of reproduction and areas occupied by reproduction or younger timber are excluded from an age class. The yields should apply to the average "forested" acre rather than to the empirical average of the entire area, including waste land. The average yields per acre on the forest will fall below this because of areas damaged, poorly stocked, or blank.

Reconnaissance under this system must now secure an index figure for each forty, giving approximate age and degree of stocking with reference to the "average" stand. These reduction factors will be used to obtain the total increment on the area. It is self-evident that in this group of forests, unless the preparation of the yield table precedes reconnaissance, no intelligent application of the yields can be made to the forest without a second examination. The reconnaissance notes on stocking must be standardized on the basis of the yield table.

Group II forests include yellow pine and the mixed conifer type of the Sierras. The distinctive character of these forests is a tendency to grow in groups rather than in a true all-aged or selection forest. The silvicultural system best adapted is group selection, removing from 60 to 80 per cent of the volume of the stand.

It has so far been considered that the only practical way of studying the increment on these forests was by measuring current growth on basis of diameter. This system of increment study has many disadvantages. It gives a fairly accurate summary of the present condition and volume of increment on existing age classes, but fails to measure real forest productiveness, which is based on age. It furnishes no basis whatever for determining the proper length of the rotation. Studies of age and growth based on age are alone able to indicate whether 100 or 200 years should be chosen as the basis of crop production. Furthermore, yield per acre and the culmination of the mean annual growth are a far more satisfactory basis for the rotation than the age at which single trees reach merchantable sizes. The current growth of a stand fluctuates more widely than its mean annual growth, and the latter should whenever possible be preferred as a gauge of production and a basis for regulation of yield.

For these reasons the writer devised a system of measuring the yield of such forests on the basis of the component age classes by area (Forestry Quarterly, volume VII, page 385). The limitations of this article will not permit of a review of the details of this method. After five years' trial in longleaf and shortleaf pine, this plan was tried in 1912 in stands on the Plumas National Forest, California, containing sugar pine,

yellow pine, Douglas fir, incense cedar, and white fir, and was fairly successful. The plan depends upon the determination separately of the three factors which give yields, namely, area occupied by each age class, average age of the class, and volume produced, and results in a yield table giving yields per acre for all ages, and mean annual growth.

The most important point in favor of this plan of increment determination is the comparative simplicity with which the yield table may be applied to the entire area of a type, thus securing the needed coördination between increment studies and reconnaissance.

The plots themselves may be taken in fairly well stocked stands; but whatever the character of the plots chosen, and no matter how much they may differ from the stand in the forest, the application to the forest is easily made. Reconnaissance data should include a tally of diameters for best results. The only additional data needed in reconnaissance is the notes on young timber. It is strongly urged that these notes be taken in the form of area approximations instead of tree counts. The enormous mortality in young timber limits the value of such counts, and the determining factor of future yield for young timber is not numbers but area stocked. Reconnaissance crews could be trained to estimate the per cent of the total area which is occupied by young timber. This figure should be conservative, as its effect is to increase the apparent yields per acre of the older stands.

The application of the yield table to the entire area of the type is based directly upon the total estimated volume of timber obtained by reconnaissance. The problem is to obtain the reduction per cent, which must evidently be applied in most cases, to allow for blanks, for stocking, etc. In the method proposed for obtaining this application of yield data to the entire area, we are obliged to assume that this reduction per cent once found will apply equally to all age classes—a not unreasonable conclusion, since the plots are selected with an eye to average conditions on the type or area—and if the relative density of age classes differs, the plots should secure this result.

In the method of growth study proposed the age classes include large groups, as veterans, mature, young merchantable, and immature, whose basis of distinction is, for the younger groups, diameter, and for the veterans, appearance and condition—that is, actual age—rather than diameter. The plots from which the yield table was made are now taken as a guide, and the stand table for the entire type is divided into age groups on the basis of similar diameter classes, and the volume for each age class computed by the use of this stand table.

The process of getting the age of each age class in the type is as follows: Height as a variable on diameter is eliminated by drawing a curve of height on diameter for the type, and thus securing a type volume table based on diameter alone. The average volume of the trees in the age class is found from knowing the total volume and total number of trees. The diameter, which corresponds to this average volume, is taken direct from the volume table, but interpolated to one-tenth of an inch. The age of a tree of this diameter is found from the growth curve of diameter based on age, prepared on a similar site by analyzing the growth on stumps. This age is accepted as the average age of the class. These operations are performed for the entire area included in the type.

The reduction per cent for yield is then found by use of the indicated yields from the standard yield table for the average age of the age classes. Divide the total volume in the age class on the forest by the yield per acre for the average age. This gives the number of "fully stocked" acres in the age class. This figure is ascertained separately for each age class and the total "fully stocked" area determined. The relation between this total and the actual area, reduced by eliminating the acreage of immature timber, gives the reduction per cent. To illustrate, assume a total area of 13,500 acres, with 1,000 acres of immature timber. The net area of 12,500 acres is stocked with merchantable timber. By the above process it is found that if the volume of timber on this area gave yields per acre equal to those of the yield table the stand would occupy 10,000 acres. Density or relative yield is therefore as 10,000 is to 12,500, or 80 per cent. This is the reduction per cent sought, and this factor is used to reduce the yield table for each age class. The reduced yields will apply directly to the average conditions on the entire type.

The area occupied by each age class may also be approximated. The per cent of the total "fully stocked" acreage, which the "fully stocked" area found for each age class represents, can be applied to the total area, thus indicating the acreage of the age class. For instance, should the "fully stocked" area in the example cited figure out for veterans 3,500 acres, for mature 2,500 acres, and for young merchantable 4,000 acres, this gives 35 per cent, 25 per cent, and 40 per cent of the total "fully stocked" area. When these per cents are applied to the actual area of 12,500 acres, the areas of the age classes are found to be 4,375 acres for veterans, 3,125 acres for mature, and 5,000 acres for young merchantable timber.

The gap between yield tables and reconnaissance is bridged in this manner by means of a comparison of the volumes in the standard yield table with the total volume in the tract, and the reduced yields should be

absolutely safe as a basis for regulation. The plan applies equally well, no matter what the density of stocking, which is an advantage in this type of forests on account of the variation in density due to dry conditions. It does not require the reconnaissance parties to record any individual reduction factors for density on each forty, as must be done to apply yield tables to even-aged forests.

The amount of office work required to apply the yield table to the forest is not excessive. It is even possible to apply the results of the plots direct to the forest, without the use of a stand table of diameters, by assuming that the areas, volumes, and stands on the total plot acreage measured represents the forest in miniature as to age classes and acres occupied by them. The total volume of the forest type might be divided into age classes on this basis and the reducing factors for yields figured out as above; but this is a much cruder method than that which requires the preparation of the stand table, for the latter gives the actual diameter classes on the type as a basis for age distinctions. The determination of the average age of the class from curves of growth in diameter based on age made from stump analyses is thought to have decided advantage over felling sample trees. Once determined such curves represent average age much more closely for mixed-age classes than can be found by felling sample trees, and the excessive cost of this felling is eliminated. The application of the growth figures is thus limited to types and qualities where logging is in progress, but by careful classification of qualities such growth figures can be given a wider application, even to forests at some distance from the site studied for growth, or correction factors can be applied to the growth curves by the felling of a few trees in the poorer or better sites.

Should this method of determining increment for forest areas prove practical after further tests, it will bring the entire area of Group II forests into the class now confined to Group I for purposes of yield regulation. The rotation and annual cut can then be based on mean annual increment, or actual average production per acre, and not on current growth.

It remains to adopt a policy for regulation which will be sufficiently elastic to meet the conditions on our undeveloped western Forests.

Regulation by area, according to European practice, undoubtedly secures rapid advance toward a normal distribution of age classes; but this beneficial result is not realized until the beginning of the second rotation, 100 to 200 years from date. To attain theoretical normality even at that date, it would be necessary for the working section or working circle to remain the same size during this period. The extreme elasticity which

railroad transportation has given to the factors of accessibility and ease of transportation has its effect in this country in permitting the formation of working sections of considerable extent, comprising in some cases several Forests. With new railroad development and changing markets new arrangements of the working sections will be necessitated. The absurdity of rigid area regulation is thus seen. Another obstacle is the impossibility of predetermined allotment of the cut to definite areas. Accessibility will continue to control sales for a long period. Area, if used at all, will be simply as a check to gauge the results of the cutting and the progress being made toward normal distribution of ages. It will not be the factor determining the annual cut.

To meet the conditions on our forests and provide an elastic system which will still interpose the needed check and guide in limiting the cut, we must depend primarily on regulation by volume; but present merchantable volume alone is an insufficient basis. Three elements must enter into a proper volume regulation: present volume, annual growth, and the actual condition and amount of timber in the different age classes, with approximate knowledge of the behavior and condition of these age classes for an extensive future period.

Von Mantel's method neglects all but the first element. The formula methods which depend on increment determination include the second, and by calculating a "normal" growing stock attempt to indicate for the forest as a whole the presence of a surplus or deficit which will modify the allowed annual cut. The third element, actual age class conditions, is almost as fully ignored by these formulæ as by Von Mantel's. In fact the Austrian formula, by allowing a period of one-half the rotation for reduction of the surplus, gives an annual cut identical with that obtained by Von Mantel's formula. The application of the Austrian method is greatly improved if based on an accurate determination of mean annual growth rather than current growth.

What is really needed is a method which gives proper weight to all three elements. Forests which have half their area covered by timber just below merchantable size will permit of a far larger present cut of mature timber than areas with the same estimated merchantable volume, but which are devoid of immature timber. The purpose of regulating the cut is primarily to secure a present steady output for immediate use, and secondarily to gauge the amount so that the cut may continue indefinitely. It is not necessary to assure an equal annual cut. Many circumstances, such as the surplus of overmature timber or temporary markets, may call for a heavier cut for the first twenty years than the Forest can afterward maintain. Volume regulation, based directly on this determi-

nation of age classes and of average yields for these age classes, fulfills these conditions. Based on these data, which can always be obtained by the proper coördination of growth studies and reconnaissance, the following system of regulation is proposed for National Forests:

The rotation is not divided into arbitrary periods; but the Forest itself is grouped into the four or five rough age classes, as decadent, mature, young merchantable, immature poles, immature saplings and seedlings, which classes served as the basis for growth studies. The rotation may coincide with the upper limit of the young merchantable age class, so that the mature and decadent groups are past the age for cutting. This is the condition in which most of the western Forests are today. The average age for each of these age groups is roughly calculated from the reconnaissance data by weighting the areas or volumes, or by the method proposed for Group II in this article.

The volume in each group is computed from reconnaissance. From the reduced yield table the average increment per acre or yield for stands of each age is stated. A properly constructed yield table would show the loss in decadent stands of advanced age as well as the growth in young stands.

Regulation is then based on the principle of removing the volume of the decadent timber within a given period. The length of the period chosen is left to the discretion of the management and will depend on the quantity and condition of decadent timber and the possibility of heavy cutting. The total cut for the period will be the present volume, minus half the loss for the period, from the modified yield table. If the stands are not decadent this condition is reversed and half the growth for the period is added. Where stands are retrograding, the shorter the period the greater the actual total saved. The calculation of the first period is the most important part of the plan of regulation, since in most cases before this period elapses, or, say, in 20 years, revised figures on estimates and growth will be taken; but as a check on this first period the possibilities of prolonging the cut over the entire rotation must be investigated. The presence of large areas of immature timber of good size should permit the more rapid cutting of the older stands. Instead of merely guessing at this prospect, the other age classes should be assigned experimental or tentative periods for exploitation, the sum of which, with the first period, should be equal to the number of years in the rotation chosen, since before the expiration of the full rotation all timber now growing, from seedlings up, will become overmature or pass the exploitable age.

The next younger class, or mature timber, would be exploited in a period beginning in the year when the volume of decadent timber is exhausted. From the yield table a volume is added to the present volume of this age class, equal to the growth during the first period, when it is awaiting the removal of the decadent timber. Then, depending on its acreage and volume, a second arbitrary period for cutting this age class is assigned to it, and one-half the possible growth or decay during this period of exploitation is added or subtracted. The possible annual cut is found as before by dividing this final total by the length of the period. The third and fourth groups can be treated in the same way. The calculation of volume and yield becomes increasingly uncertain the more remote the period, but its relative importance decreases in like proportion.

Should it appear that the first arbitrary assignment of periods gives very irregular yields, it is possible to alter the length of the periods and recompute the yields from the reduced yield table. Since this is done for the whole age class, it involves very little extra calculation. The desired equalization of yield can be approximated by trial. The usual conditions, however, will call for a heavier cut of overmature timber than for the remaining classes. It would be just as practicable to determine, for the immature class of timber, the per cent of total area occupied and assign to it a period at the end of the rotation equaling this per cent of the total rotation, thus eliminating the calculation of yield on this age class.

Nothing original is claimed for this plan of regulation. The principle was laid down in 1795 by G. L. Hartig, and the idea is the same, but cut loose from all burdensome restrictions of stand allotments and prescribed areas for cutting, with their detailed yield computations. The advantages of the method are that the commercial factors of demand and markets, as well as the condition of the stand, can be given full weight in fixing the limits of the annual cut, actual increment is fully recognized, and sustained yield is assured by recognition of the amount and relation of the actual age classes.

One factor in regulation of virgin forests is the inaccessibility of portions of the area. The method theoretically calls for the removal of the decadent timber before the next age class is cut. In actual practice perhaps half the area will be accessible in the first period, and upon this half all of the second or mature group will be reserved along with the veterans, leaving the Forest in the inaccessible portion still in its virgin condition. In this case the loss due to decadence continues unabated on the remaining half, while the cutting area is covered in half the time or for double the cut otherwise called for. When this condition is anticipated, both increment calculation and regulation of the cut may be computed on the

basis of the actual anticipated operations. On the inaccessible half the condition of the Forest at the end of the period of exploitation of the remainder can be predicted from the yield table, and will depend upon the relative proportion by area of the different age classes at present. Upon the exploitable area both the veteran and mature age classes can be considered as being cut progressively in the same period. The calculation of the annual cut would be made separately for each for an identical period, and the total cut is the sum of the cuts for both age classes. If the diameter limit chosen for cutting does not coincide with the rough limits of an age class, the approximate proportion of the total age class which is exploitable under the limits chosen gives the basis for computing the yield and cut for the period.

The method seems sufficiently elastic and practical to be offered as a possible standard for regulation in all Forests whose increment per acre and age classes can be determined, and as such it has been termed by the writer for convenience the "American" method of regulation.

The question of applying this method of regulation to the remaining group of forests—Group III on all aged forests—hinges on the possibility, not yet demonstrated, of getting satisfactory figures on yields based on age and areas rather than on mere current annual increment for such forests. This group may be narrowed down to such species and types as are represented by Engelmann spruce. A method of measuring yields in this type by investigating the space occupied by crowns of trees of different diameter is being tested, but the discussion of this method does not come within the scope of this article.

MANAGEMENT OF WESTERN WHITE PINE IN NORTHERN IDAHO

BY NELSON C. BROWN

Contributed

From the viewpoint of economic utility, wide demands on the markets, and favorable silvicultural characteristics, which are the determining factors in successful forest management, the western white pine, although individually not distributed over a great range of territory, is one of the most valuable trees in the West for future management. It is a tree of splendid proportions, occurring up to 8 feet in diameter and 200 feet in height. It usually forms about 50 to 60 per cent of the total stand in the Northern Idaho forests. The tree cleans itself of limbs admirably, and it is one of the best lumber trees in the entire West. The Potlatch Lumber Company recently cut over 31,000 board feet of lumber from a single tree near Collins, Idaho.

RANGE AND OCCURRENCE

Western white pine ranges from the lower elevations in British Columbia south to the high mountains of southern California and from western Montana to the coast in Washington. Its optimum, however, is found in northern Idaho, where it reaches its greatest commercial importance. In fact, it only occurs in isolated bodies outside of the "pan-handle" of Idaho and contiguous portions of Montana and Washington. It is primarily a tree of the deep, rich soils at elevations from two thousand to three thousand five hundred feet above sealevel. Its rapid growth is dependent upon fertile, well-drained soils and favorable climatic influences, such as heavy rainfall and comparative evenness of temperature. In northern Idaho the precipitation ranges from thirty to fifty-five inches per annum, including an exceedingly heavy fall of snow from November 1 to April 1. It is commonly found on favorable north slopes, where a moist, well-drained soil occurs, but it is never present on southern aspects or on high, rocky elevations. It is the dominant tree along with the western larch in the northern Idaho forests. These two species usually form the upper story of a two-storied forest. The lower story is composed of western red cedar, western hemlock, and white fir. Douglas fir is occasionally associated with the western white pine as a co-dominant tree in the crown cover. Stands up to 150,000 board feet per acre are common, and timber sales have been

made cutting from 50,000 to 60,000 feet per acre over considerable areas. White pine reaches its best development in mixed stands, although it occasionally occurs pure in small patches.

MARKETS AND USES

The western white pine, both in the quality of its wood and external appearance, is very similar to its near relative, the eastern white pine. The chief difference in external appearance is the cigar-shaped crown in contrast to the more spreading branches of the eastern pine. The wood is inclined to be more pinkish in color and the bark is not nearly as thick as in the eastern variety. As is commonly known, white pine has a greater variety of distinct uses than any other wood in the country, and both the eastern and western white pines are used interchangeably for the same purposes. The western species is now coming into great demand for use as match stock. On the eastern markets, even as far as New York, it commonly undersells the eastern white pine from $3 to $5 per thousand for companion grades. Its demand on the western markets is best appreciated by a comparison of its stumpage value with that of species from the same region. Western white pine brings from $4 to $6 per thousand board feet on the stump, whereas Engelmann spruce and western yellow pine bring about $3 and western larch and Douglas fir from $1 to $2. Northern Idaho is traversed by four transcontinental railroads and their many branches, giving excellent transportation facilities for marketing forest products under the most advantageous conditions.

SILVICULTURAL CHARACTERISTICS BEARING ON MANAGEMENT

In rapidity of growth the western white pine, under favorable influences, is one of the most rapid growing trees in the West, probably second only to the Douglas fir. Seedlings have been measured showing an average growth of 20 inches in height per annum over a period of several years. It will commonly produce from five hundred to one thousand board feet per acre per annum. In tolerance it is about medium, being not nearly as intolerant as the Douglas fir or larch, nor as tolerant as its other associates, western red cedar, white fir, and western hemlock. It will stand suppression, however, over a great period of years. One small tree, only 3½ inches in diameter, was found to be 137 years old; another tree, after growing rapidly for the first 15 years, stood suppression for over 100 years and was still healthy in its external appearance. Western white pine is not very fire resistant; a severe ground fire burning over the needles will commonly scorch through the

cambium layer and kill the tree. This is an important factor in fire protection, especially in connection with brush disposal. Mature trees are very apt to be attacked by heart-rot, so that the per cent of cull in over-mature timber is frequently as high as 25 per cent, although the average under all conditions is about 12 per cent. Altogether, however, it is comparatively free from insects and fungous attacks. Owing to a broad, shallow root system, it is very liable to windthrow.

It is a prolific seeder, and reproduces thriftily on cut-over areas. It seeds abundantly every five to seven years, but some seed is produced nearly every year. Its seed has been known to carry distances of nearly one mile, and it restocks itself readily on cut-over or burned-over areas up to one-half mile. Its seeds require a mineral seed bed for germination. In competition with other reproduction it is always successful, and forms the dominant portion of nearly every area restocking with young growth. Altogether natural reproduction in this region is very thrifty and is always assured whenever fires are kept out.

SILVICULTURAL MANAGEMENT

A great variety of silvicultural systems have been experimented with in cutting western white pine. The selection system and several kinds of clear-cutting, with seed trees left both individually, in groups, and in strips, have been tried. In the early timber sales on the Kaniksu National Forest, clear-cutting was tried, leaving from six to ten tall, vigorous seed trees per acre. On account of the shallow root system, the seed trees were readily blown over as soon as the clear-cutting was finished.

The selection system with the diameter-limit adaptation has also been tried but with poor success. If the stand is opened too much, the trees are liable to windthrow. On the other hand, if the stand is not opened up sufficiently, reproduction on account of its comparative intolerance does not develop sufficiently and compete successfully with the overwood. In addition, in these dense northern Idaho forests, logging under the selection system is expensive and the stumpage price must be sacrificed somewhat.

Clear-cutting and leaving seed-plots, consisting in the aggregate of about 25 per cent of the area, was next tried, and there is every reason to believe that this system of silvicultural treatment will be successful. These seed-plots have not been left with any regularity, either in size or distribution. They consist of healthy, middle-aged trees left on vantage points for seed distribution, such as on hilltops, projecting ridges, along steep slopes, etc. However, there are several disadvantages in this

method. In the first place, there is a great deal of capital tied up in the trees left standing in the seed-plots, which is not offset by increased growth. Secondly, this system works a hardship on the logging contractor in forcing him to cut around the seed-plots, thus increasing the cost of skidding and hauling and the unit cost per thousand. Besides these, there will undoubtedly be a difficulty encountered when the time comes to log off the seed-plots. They will, presumably, be cut when reproduction has been established. Logging these seed-plots will cause considerable injury to reproduction. The stumpage price will have to be lowered considerably on account of the small and isolated areas logged, and, in addition, there will be no provision for reproduction on the seed-plot areas themselves, unless they are cut just after a seed year or else planted.

To meet these objections, planting by the contractor has been suggested. This would mean an added cost, and a commensurate reduction in stumpage price would have to be made. Whether planting would be successful, and whether it should be done by the Forest Service and charged to the lumberman, or done by the lumberman under supervision of the Forest Service, are still questions to be solved. Another objection has been met in the legal aspects of the situation; that is, it may not be possible to reduce the stumpage price on National Forests in consideration of the added cost of planting.

Brush disposal has always been an exceedingly important question in the management of western white pine. Northern Idaho presents conditions which are probably the extreme in fire risk in the whole country. These conditions are the long-continued dry periods, frequently from early spring until late in the summer; the immense accumulation of dead and down timber and inflammable brush in the forest, along with the thick, dry duff and the continuous, dense coniferous forest cover on steep topography unbroken by natural conditions for fire protection, such as mountain parks, broad rivers, treeless areas above timber line, etc.

At first, piling and burning brush was adopted. This cost from 50 cents to $1 per thousand. After logging there is always an immense accumulation of brush, tops, and waste material on the ground which should be burned, both to reduce the fire hazard and to provide a mineral seed-bed for the germination of seeds. It was found that a reduction in stumpage price was necessary to provide for this extra cost of brush piling and burning. To overcome this high cost, burning broadcast was tried. Brush on clear-cut-timber sale areas is sometimes from 3 to 6 feet deep on an average over the whole area, and this method has proven very successful. It was necessary, however, to clean out a strip from

50 to 75 feet wide around the entire area before the brush could be burned without injury to the seed-plots or adjacent standing timber. The question of spring or fall burning became an important one. When the brush was burned broadcast in the spring, smoldering logs and stumps added considerably to the fire risk in the summer season. Some of these logs and stumps would smolder for two months or more. On the other hand, fall burning presented the difficulty of unsatisfactory results, due to early fall rains or else the liability of a dangerous forest fire resulting from too early burning. It was found that burning broadcast cost only from 3 to 6 cents per thousand and obtained very much better results as far as getting rid of the brush and providing a mineral seed-bed were concerned.

In clear-cutting methods it was aimed to get rid of the hemlock, which is a very prolific seeder. In northern Idaho hemlock is unmerchantable on account of the heart-rot which is present in practically every tree of merchantable size. It is, therefore, the worst kind of a forest weed. To get rid of the hemlock it was found necessary to slash down all the remaining trees on clear-cut areas, so that the pine would have a chance to seed up from the seed-plots without dangerous competition from the hemlock already present on the logged areas. This slashing has cost all the way from 2½ cents to 12 cents per thousand. It was found that there was an average of about 50 trees from 2 to 40 inches in diameter per acre left after logging to slash. Winter burning has been tried, but it has not proven a positive success as yet.

On account of its comparative intolerance and favorable regenerative qualities, western white pine should be managed on some clear-cutting system, with reproduction secured either from seed-trees in plots or in strips. If it is found inadvisable to leave seed-plots or strips, artificial reproduction will have to be resorted to. It is certainly not a tree adaptable to management under the selection or shelterwood systems.

ROTATION AND YIELD

Western white pine can be managed successfully on rotations of from 40 to 70 years. The aim should be to grow mixed stands rather than pure stands, because of the better quality of the timber and the greater production per acre in mixed stands. Maximum yields from 120,000 to 150,000 board feet per acre are possible on longer rotations. With the development of market conditions in northern Idaho, it will undoubtedly be possible in a few years to make profitable thinnings. Market conditions in northern Idaho are probably as good as anywhere in the West, on account of the intensive development of agriculture,

excellent transportation facilities, rapid growth of manufacturing industries, and the great influx of settlers throughout this productive region.

From figures gathered by F. I. Rockwell on the Kaniksu Forest, the following table is presented to show the normal and empirical yields in stands of white pine which averaged 80 per cent pure. Plots were measured on both the bottoms and lower north slopes for this table:

Age in years	Normal yield per acre	Empirical yield per acre
40	14,000	10,000
50	26,000	18,000
60	39,000	27,000
70	51,000	35,000
80	63,000	44,000
90	76,000	52,000
100	88,000	61,000
110	100,000	69,000
120	113,000	78,000
130	125,000	86,000
140	138,000	95,000
150	150,000	103,000

Based upon the above empirical yields, the following soil expectation values were determined. From this table it will be seen at once that the 50-year rotation is the most profitable. However, it may not be possible to establish natural reproduction immediately after cutting, as presumed in this table.

Length of rotation in years	Empirical yield Feet B. M.	Soil expectation value
40	10,000	$43.20
50	18,000	52.25
70	35,000	49.57
100	61,000	32.48
120	78,000	22.13
150	103,000	11.37

In deriving the above values the following table was used:

$$\text{Soil expectation value } (S) = \frac{Y - C \times 1.0p^r}{1.0p^r - 1} - E.$$

When Y = Yield per acre in thousand board feet × $10 (estimated stumpage value per M).

p = Annual rate of interest, 3 per cent (Government rates).

r = Number of years in rotation.

E = Capitalized cost of administration (3 cents per acre).

C = Cost of establishing stand. (No cost is used here, for it is estimated that sufficient restocking will take place under the clear cutting system of regeneration.)

THE HIMALAYAN FORESTS

BY W. H. GALLAHER

Contributed

The coniferous forests of India are of peculiar interest to the American forester, both on account of their resemblance to those found in many parts of the United States and because silviculture, though practiced for 40 years, has not yet assumed that artificiality so often characteristic of European forestry. The timbered areas under scientific treatment are still in the transition stage between a virgin and an intensively managed condition. Hence the success or failure of different silvicultural methods in India can often be a criterion of similar methods in our own country.

The visitor to the hill region of northern India is first impressed by the remarkable similarity existing between the altitudinal types of the Himalaya and the Sierra Nevada Mountains—a likeness which is so close that the individual species found at corresponding elevations in each region are almost duplicates. Hence the characteristics and the problems of management of the Himalayan forests can be shown most clearly by a comparative description.

At low elevation, usually below 3,500 feet, on the outlying ranges of the Himalayan hills lies a hardwood zone roughly corresponding to the oak, chaparral, and digger-pine belt of the Sierras. It yields little or no saw timber, is coppiced on a short rotation to produce cordwood, and is more characteristic of the plains woodlands than of the true mountain forests.

Above the hardwoods, beginning approximately at 3,500 feet, chir pine (*Pinus longifolia*) makes its appearance. This tree is the counterpart of yellow pine (*Pinus ponderosa*) during the sapling and pole stages. Its long leaves, three to a bundle; cones, three to four inches in length; straight, cylindrical bole, yellow bark, and strong, resinous wood all manifest the unmistakable similarity between the two species. In old age its crown does not have the long, narrow, columnar shape so characteristic of yellow pine, but rather the irregular or rounded head of the long-leaf.

The species most commonly associated with chir are ban (*Quercus incana*), burran (*Rhododendron arboreum*), aiyar (*Pieris ovalifolia*), and to a lesser extent maples, horse-chestnut, and others. It exhibits,

however, a marked tendency to form pure and often even-aged stands, forcing out other species except the more tolerant ban. Under any conditions the associates are of little importance, as the entire merchantable content, which averages 10,000 to 12,000 feet, b. m., per acre, is composed of chir. The formation of even-aged stands is particularly easy on account of the prolific seed-bearing capacity of the mature trees and the astounding success of the seedlings in competition with the heavy grass cover which is typical of the region.

The chir type is encountered between 3,500 and 6,500 feet, or at elevations usually populated by various Hindu hill tribes, which are both agricultural and pastoral in occupation. The timber cover is consequently frequently interspersed with comparatively extensively cultivated areas of farming and grazing land. Since most of the hardwoods, especially ban (oak), are lopped annually to provide winter browse for sheep, goats, and cattle, and a considerable percentage of the chir zone is covered with the ban type, large tracts have deteriorated to open low scrub. This condition is being remedied, so far as is possible without undue hardship on the part of the villagers, by systematic regulation of grazing and prohibition of lopping on areas under administration.

Chir is customarily treated under the shelterwood system. The first working plans proposed the removal of the stand in two fellings, but this proved unsatisfactory in many cases and it has been found necessary to adopt more intensive methods. Later rules prescribe a heavy preparatory or seed cutting to remove about two-thirds of the stand, and a series of after-cuttings at intervals of about four years. All small trees, as well as deteriorating and unhealthy ones, are felled, and strong emphasis is laid on leaving the best seed-bearers, even though they may not be adding increment with such rapidity as other faster-growing but less productive ones. Fifteen to twenty trees per acre are left after the seed felling, six to eight after the first removal felling, one to two after the second, and all are taken on the third. The last seed-cutting within a periodic block is finished ten years before the end of the period, so that there may be no doubt about getting the whole regenerated within the allotted time. While fellings are customarily about four in number, the present tendency seems to be toward fewer cuttings, with more consideration for the needs of each individual patch rather than the whole compartment, and to lay stress on the fire danger, since fire, once started, is usually of such intensity as to destroy all living trees, large and small. The diameter limit is commonly fixed at 28 inches, with a rotation of the number of years needed to attain this size, as obtained from growth figures based on trees in the virgin forest. No yield tablets

for even-aged stands such as are produced by the shelter-wood system exist, and it may be necessary in the future to change both rotation and diameter limit. Hence the figures used are very conservative, due to the well-known fact that the culmination of the mean annual increment of the individual trees does not coincide with that of the stand, but is much later. It is admitted that if it were not for some loss in conversion a smaller exploitable diameter and a corresponding rotation would be more profitably employed, but 28 inches seems most satisfactory at present, all things considered.

Each working circle is divided into a number of equi-productive blocks and the rotation into a similar number of periods, during which each block is in its turn regenerated. On the Juansar Forest the regeneration period of 35 years and a 140-year rotation give four periodic blocks, these being again divided into four compartments for convenience, although fellings are prescribed by the periodic block. Ten years before the end of the first period the stand remaining in the periodic block under regeneration is reëstimated and the result is divided by 10 to obtain the annual cut for the last 10 years. In this way any inaccuracies in the estimates are spread over 10 years.

Occasionally the selection system is followed in treating chir. Such is the case on the Nanai Tal Forest, where much of the stock of merchantable timber had been removed before the inauguration of systematic management necessitating a conservative cutting policy. The group or patch selection system is employed with the idea of improving the condition of the stand and bettering its yield. It is generally accepted, however, that chir is not adapted to this treatment, and it is employed only under such adverse conditions that a clear-cutting policy is impossible.

Systematic light burning is successfully carried on in many working circles. Large areas are burned yearly in the cold months for the double purpose of providing better grass and in order to reduce the fire danger near stands being regenerated. The practice has the additional advantage of killing off ban (oak) seedlings which are prone to come in on protected areas. It is, of course, employed only in forests felled under the shelterwood system, where it is imperative to protect the areas densely stocked with young trees till they are past the age where they will be killed outright by surface fires.

The chir yields an excellent grade of turpentine and has been successfully worked of late years, practically driving foreign competition out of India. The most up-to-date cup-and-gutter system is used. The three-inch faces are chipped every eight days and worked up to a

height of about eight feet. Trees under 18 inches in diameter are not tapped; those 18 to 24 inches in diameter have one cup, and trees over 24 inches have two. The yield is four to ten pounds of gum per tree for the season.

Above the chir pine lies the deodar (*Cedrus deodara*) belt, usually between the elevations of 6,000 to 9,000 feet. In its optimum range, between 7,000 and 8,500 feet, deodar often constitutes the predominant tree in the forest, which averages about 17,000 feet, b. m., per acre. Commonly associated with it are kail (*Pinus excelsa*) and moru and ban oaks. In the upper limits of the zone karshu (*Quercus semecarpifolia*), spruce (*Picea morinda*), and silver fir (*Abies webbiana*) form an increasing proportion of the stand, while deodar is confined to the ridges and well-drained slopes. No tree with the same characteristics as the deodar is found in the Sierras, but by drawing the altitudinal limits of the zone closer together and regarding its associate, kail, as the key tree, the sugar-pine type is closely approximated. Kail, like sugar-pine, is classified in the white-pine group, having bluish-green foliage, five leaves to a bundle; long, horizontal branches, drooping cones, grayish-brown bark, and soft, easily worked wood, slightly darker in color than sugar-pine. Its most noteworthy characteristic as compared with sugar-pine is its capacity for reproducing in such quantity as to almost exclude the more valuable, but in youth slower growing, deodar.

Since the greater part of the deodar forests contain other and unsalable species often in large quantities, no clear-cutting system can be introduced. Furthermore, the climatic dangers are probably too severe to allow the introduction of any such method. The type lends itself naturally to the selection system which in practice is made as patchy as local conditions will allow. Groups average a quarter of an acre in extent, although many are larger, especially where there is an abundance of reproduction already upon the ground. In mixed forests openings around seed-bearing deodar are made by felling or even girdling other species.

The diameter limit is customarily 28 inches, with a rotation of 150 years. Regulation of cut being by the single-tree method, this diameter limit must be strictly followed, except with badly diseased or dying trees, in spite of the fact that accurate volume-growth figures are extremely difficult to obtain. The inelasticity of the method is clearly apparent in many compartments where good silviculture apparently demands a less rigid application of the diameter limit. Since the felling of merchantable species other than deodar is regulated by area, the number of

compartments is a multiple of the felling cycle of deodar, which is, in turn, a submultiple of the rotation, or most often 15 years.

Kail, by reason of its superior height growth in the seedling and sapling stage, often crowds out deodar. It was formerly regarded as a weed tree, but a rapid increase in value of late years, coupled with its rapid growth, has rendered it less obnoxious to the forester. Whereas it was formerly cut or girdled to favor even scattered deodar, it is now touched as little as possible, and is favored on areas not particularly adapted to deodar. During the systematic cleanings which are made every 10 years, only those trees which are suppressing healthy deodar are felled or girdled, or, if not directly above, pruned of branches to a distance of six to eight feet above the top of the deodar. All other species are accorded a similar treatment in favor of kail.

Grazing is so handled as to be of very material assistance in regenerating cut-over areas in the deodar type. A cut-over compartment is heavily grazed for two or three years, the sheep and goats tearing up the ground cover and trampling down the dense undergrowth; then the area is closed to grazing, allowing an opportunity for reproduction to come in. After about seven years the accumulation of brush and grass has become so dense that further regeneration is impossible, while seedlings already upon the ground are so well established that they will not be killed by sheep. Therefore the tract is reopened to grazing, allowing the brush and grass to be trampled out and eaten, and unregenerated patches have a second opportunity to seed in when the compartment is closed. This alternate opening and closing is repeated till the young seedling growth is uniformly established and the entire area is permanently opened to light grazing.

At about 9,000 to 9,500 feet the deodar disappears, giving way to the fir and spruce. Silver fir (*Abies webbiana*) and spruce (*Picea morinda*) are the chief components of the type which may be likened to the red-fir belt of the Sierras. The forest is patchy, dense stands alternating with open glades or rocky outcrops, and the region as a whole assuming subalpine characteristics. Upon rocky south slopes deodar is found well above 9,000 feet clinging to the steep precipitous slopes. Here they are inaccessible to logging operations, even as carried out in India, but act in preventing snow avalanches from starting, as well as adding greatly to the picturesqueness of the region. On the other hand, fir and spruce descend into the deodar zone on cool, north slopes and canyon sides. Other species found within the type are maples, service trees, yew, and karshu (*Quercus semecarpifolia*).

While the forest is patchy, individual stands are very heavy, often running 30,000 to 60,000 feet, b. m., per acre. (The estimates given here were made by the writer ocularly upon the ground. Indian foresters make tree counts by six-inch-diameter groups, and these are not converted by means of volume tables into cubic or board foot measure.) The timber is very defective from heart-rot and shaky butts, and lies so far distant from drivable streams that it is practically unmerchantable at present. Limited areas are cut in the vicinity of a few hill towns to supply the local demands for firewood, but, like their American relatives, spruce and fir are poor fuel woods. Where cut the selection system is followed, cutting being very light on account of danger of wind-throw and snow-break and as a protection to the younger age classes.

Each altitudinal zone has a well-defined oak type. Ban oak through the chir belt plays an important part in providing fuel to the villagers and winter food to their live stock. Both moru and ban oaks occur in the deodar zone, though seldom forming pure stands of any extent. In the fir spruce type the Karshu is often of importance. At high elevations, principally above the well-defined fir and spruce areas, it forms pure stands which are quite unlike anything in America in similar situations. The sensation of passing through a well-defined subalpine type into a dense stand of leathery-leaved evergreen oaks festooned with tattered strips of dark-colored moss is never forgotten.

The oak types are occasionally merchantable for cordwood, this of course depending upon their proximity to towns demanding a supply of fuel wood. Coppice with standards is best adapted to such stands. The rotation is usually 40 years, leaving 10 to 30 standards per acre, a portion of these being removed after each felling. Growth is extremely slow, particularly at higher elevations, and it is with great difficulty that the type can be profitably handled.

Artificial regeneration in India is still in the experimental stage. The cost per acre of successful planting has been found to be incommensurate with the probable financial returns. Furthermore, the most important coniferous species reproduce naturally so well that artificial methods are seldom necessary. Deodar has been experimentally planted on areas at present understocked or covered with unmerchantable oak. Work must be performed with the utmost care; plants are transplanted from small wickerwork pots, where they have remained during their last year in the nursery; a mat of grass and leaves is formed about each plant in order to hold moisture: and grass must be cut away in the plantation for about five years. Kail is often successfully sown by seed-

spots and is a species well adapted to this method. Plantations which cost 6 to 20 rupees per acre—an equivalent of $60 to $200 under labor conditions as they are in the United States—are seldom entirely successful, in spite of the care and thoroughness with which the work is carried out.

Cheap labor in India has made possible logging and exporting methods which are impossible in the United States. It has furthermore enabled the construction of excellent trail systems and export roads without great expense in a region difficult of access. Fire-lines, which must be biannually cut over and burned, have been constructed at critical points within the fire danger zone, and are kept in good condition at an expense which is commensurate with their value to the forest administration. In fact, all technical questions assume a different aspect where labor is readily obtainable at $3.30 a month. Therefore the manner of solution of such problems in India is no criterion of their probable solution in America. Nevertheless the character of work which will prevail and the results that will be obtained 20 years from now in some parts of the United States can be as clearly seen in the Himalayan Mountains as anywhere in the world.

METHODS AND COST OF BRUSH PILING AND BRUSH BURNING IN CALIFORNIA

PREPARED IN THE FOREST SERVICE BY J. ALFRED MITCHELL

INTRODUCTION

In the mixed forests of California piling and burning has come to be the accepted method of brush disposal on National Forest sale areas. This is due to three things: the necessity of rendering cut-over areas as immune from fire as possible; the general belief that under California conditions the protection of the litter is not needed to insure reproduction; and finally, a desire to render the areas as sightly as possible. While the last is purely a superficial reason, it has undoubtedly played an important part in the popularity of this method of brush disposal, both here and elsewhere. The second reason, although frequently advanced, has not yet been conclusively determined, for while, under favorable conditions, satisfactory reproduction has been secured where the brush has been piled and burned, in other instances no reproduction has come in. Whether or not this has been due to the manner of brush disposal, however, is not known. Protection is then the primary purpose of brush disposal in District 5, and the chief reason for the adoption of the method.

The purpose of this article, however, is not to discuss the reasons for piling and burning, or the ultimate results, but to summarize briefly the details of the method in use and its cost as reported.

Conditions Involved

Sales of government timber in District 5 have been largely confined to two types of forest, viz, the more or less open stands of yellow and Jeffrey pine peculiar to northeastern California and the drier situations throughout the State and the mixed stands of yellow pine, sugar pine, white fir, Douglas fir, and incense cedar in varying proportions, found west of the Sierras. Conditions in these types differ widely, and the difficulties encountered in brush disposal vary in proportion. In the open yellow-pine stands, for example, openings are frequent, the quantity of brush is small, it burns readily, and the danger of fire spreading is not great if ordinary precautions are taken. In the mixed conifer stands, however, it is often difficult, if not impossible, to find a place where the brush can be piled for burning at a safe distance from standing trees and reproduction. The quantity of brush is also larger, and the difficulty both of burning

and of controlling a fire once started is much greater. One other type in which the difficulties of brush disposal are even greater might also be mentioned in passing. This is the red fir or subalpine belt, where the density of the stands, the quantity of brush, and the depth of litter make brush piling and burning a most difficult and hazardous operation. Sales in this region, however, have been few and the disposal of brush has consequently not been a serious problem.

From this brief summary of conditions it will be seen that up to this time the greatest problem has been the disposal of brush under conditions prevailing in the mixed conifer forests, since the difficulties experienced in the open yellow pine are nominal and sales in the high fir belt have been few.

BRUSH PILING

Time of Piling

Experience has shown that the sooner after felling the brush resulting from the tops and lops is piled, the more expeditiously and satisfactorily it can be done. In the case of yellow pine thorough drying renders the branches brittle and reduces the chopping necessary in trimming up the tops. The smaller branches and needles, however, break off in handling. Thus while somewhat less effort is required in trimming, time is lost in picking up the small branches, and the result, as a whole, is less satisfactory. With other species than the pines the difficulty of handling is much increased by delay, owing to the fact that the branches in drying become tough and elastic and are exceedingly difficult to cut. Lying over winter further increases the difficulties, the weight of the snow causing the branches to become matted and hard to separate.

As a rule, the best time to dispose of the brush is immediately after felling. The objection frequently advanced to this procedure, however, is that in removing the logs the piles become disarranged and have to be remade. On the face of it this seems to be a valid objection, but where this method has been tried out in good faith it has been found that the increased ease of logging, owing to having the brush out of the way, in most cases more than offsets any additional work necessary to repair the damage done to the piles. The real objection in the minds of most lumbermen arises from the fact that they consider brush piling as a separate operation and not as a part of logging, and find it more convenient to segregate brush piling and logging costs by employing separate crews and doing the work at different times. As a matter of fact, where brush piling is to be done it has been found more economical to consider it as a part of the logging operation and to have the work performed by the swampers at the time the trees are limbed. While this requires more men at the

time to keep ahead of the loggers, the result is more satisfactory all around. In any case it has been proved to be most economical to limb the trees clear to the tops at the time of felling, although piling may have to wait and be done later. In no case, however, should piling be delayed beyond the fall in which the cutting is done.

Position and Size of Piles

In open stands the size and proper placing of brush piles is a simple matter, as openings are large and plentiful and the quantity of reproduction is usually small. Where the timber is heavier, however, considerable judgment is often necessary to pile the brush to the best advantage. Not only does the density of the standing timber and the abundance of reproduction render brush disposal difficult, but the heavier cut and the presence in greater proportion of the more tolerant species, viz, firs and cedar, with their persistent limbs, adds considerably to the quantity of brush to be disposed of.

The position and size of brush piles under these conditions is the most important consideration in proper brush disposal. To begin with, the size of the piles should be proportioned to the size of the opening and the proximity of reproduction, since a large pile, no matter how carefully burned, will generate more heat than a small one and consequently do greater damage. Secondly, the piles should be so placed as to take advantage of slope and prevailing winds, in order that the heat may, as far as possible, be carried away from the growth it is desired to protect.

It is a known fact that fire burns more fiercely up hill than down, and that wind is an important factor in controlling it. Thus piles may be placed closer to the uphill side of standing trees and reproduction than to the downhill side, and nearer to the leeward than to the windward. By taking advantage of these facts brush may often be piled where it can be burned with safety, while otherwise it would have to be left unburned or carried a considerable distance at greatly increased expense. These, however, are the refinements of brush piling and are not to be expected of the ordinary brush piler. It is surprising, however, how soon they tumble to these things when they have the interest of the work at heart. The ordinary precautions, such as piling the brush away from trees, stumps, logs, and reproduction, are of course essential, and are usually observed when the necessity of it is sufficiently emphasized.

Character of Piles and Methods of Piling

Next in importance to the proper size and placing of the brush piles is the way in which they are built, for on this depends largely the readiness and completeness with which they will burn. The familiar phrase,

"brush to be piled in small and compact piles," gives the secret of satisfactory brush piling. While the piles need not necessarily be small, they must be compact. To this end limbs over three inches in diameter should seldom go into the piles, and branches longer than five or six feet should be cut in two.

Round piles usually burn better than long ones, since they are ordinarily more compact. Along skidding trails and roads, however, long piles are often more economical to burn. Experience has also shown that to burn to the best advantage the height of a pile should equal, if not exceed, its diameter, and that, as far as possible, the butts of the limbs should be placed toward the center of the pile. If this is done, the piles will burn readily and require the minimum of attention to insure a clean burn.

There is considerable difference of opinion as to the proper disposal of the larger limbs and tops. Some contend that they should be burned, while others believe that they may as well be allowed to lie on the ground and rot. Whether the latter procedure increases the danger of fire or insect infestation sufficiently to warrant the added expense of disposing of the larger limbs is still an open question, some contending one way and some another. From the standpoint of looks it must be admitted that burning is desirable, but this alone does not justify the expense involved.

In any case the method of piling should be the same, since the larger limbs, if they are to be disposed of, can be burned to the best advantage by standing them on end about piles built as already described. Piles constructed in this way have somewhat the appearance of small wigwams, and when burned the larger limbs fall across the fire as it burns down and are more or less completely consumed.

Labor and Tools

While the character of the timber, and, to some extent, topography, are items that increase or decrease the difficulties of satisfactory brush piling, efficient labor is by far the greatest item. Unfortunately brush piling is too often looked on both by operator and logger as low-grade work worthy of little consideration. As a result the cheapest class of labor is usually employed, and lumber-jacks have been known to quit when put on this work.

Cheap labor would not in itself be so unsatisfactory if properly supervised. Too often, however, the men employed to do this work are turned loose to shift for themselves with the idea that any old way will do as long as they get over the ground. As a result the work is done indiffer-

ently, the men feeling that the work is beneath them and that it is all foolishness anyway. Another potent source of dissatisfaction is that frequently a small crew of two or perhaps three men are turned loose on a slash of from 40 to 160 acres with orders to "go to it and eat it up," and are given no further attention except an occasional visit from the foreman, who wants to know what makes them so blamed slow. Even though a crew of this size works industriously, the work accomplished in comparison to the work ahead looks so infinitesimal that most men in a few days come to look on it as a hopeless task and make little effort to do more than put in their time. In one instance of this kind two old pensioners of the camp were put to work on 80 acres of fir slash, and each one hobbled around all summer with a cane in one hand and a hooked stick in the other piling (?) the brush. In this case the cost of piling was reported by the operator as 55 cents per thousand feet b. m., and a wail went up at the unreasonableness of Forest Service regulations.

All these difficulties could be overcome, the quality of the work improved, and the costs reduced by first of all employing men physically able and willing to work; second, providing adequate supervision; and, third, a sufficiently large force, so that the men can see that progress is being made from day to day, and that they are not up against a hopeless task. That this can be done successfully is proven by the fact that in almost every instance where brush piling has been contracted it has been done cheaply and to the satisfaction of all concerned.

This brings up the question of the advisability of contracting this part of the logging operation. Where the operator has not the time or inclination to assume this responsibility, with the idea of giving it serious consideration and considerable attention, it can probably be handled to the best advantage by contract if experienced brush pilers are available. On certain sales on the Plumas this method was in vogue during the past year and proved satisfactory to all parties concerned. The contractor in this instance received from 20 to 25 cents per thousand feet b. m., depending upon the character and quantity of brush to be handled, and made good wages out of it both for himself and his men. On the other hand, if the operator would give the matter the attention it deserved, consider it as a business proposition and handle his men accordingly, the margin of profit the contractor finds in it could certainly be saved.

In California foreign labor, preferably Italian, for this class of work is, if properly supervised, probably the cheapest. There are two fundamental reasons for this aside from wages. In the first place, the foreigner is usually not afraid of work, and in the second does not consider his work beneath him. In addition he is usually as quick to grasp the

idea of how the work is to be done as the average "white man" and can generally be trusted not to soldier on the job. On the other hand, the average woods worker who has not raised himself out of the "swamper" class is too often either lazy, incompetent, or both. As a rule, too, he is too good for his job, takes little or no interest in his work, and if left alone is pretty apt to spend his time in seeing how little he can accomplish.

Ordinarily a crew of six or eight men, one of whom knows how the work should be done and who is responsible for it, work to the best advantage. The men usually work in pairs, the foreman working with them, since after the first few days the men need little instruction, and all that is necessary is to keep an eye on the way the work is being done.

The most satisfactory equipment consists of a sharp, single-bitted axe that can be used readily with one hand in cutting the smaller branches. The advantage of having one hand free to hold and dispose of the branches as they are cut up is obvious. In addition each pair should be provided with a regulation double-bitted axe for limbing and cutting up the larger branches.

Cost of Piling

The cost of brush piling varies from 20 to 63 cents per thousand feet b. m. and from $2.34 to $9.30 per acre. The cost per acre, however, is affected by the density of the stand as well as the efficiency of the work and the species involved, and is not therefore a fair basis for comparison. Although the cost of brush piling per thousand feet b. m. is affected to some extent by the species concerned, the character and density of the remaining stand and reproduction, still, as has already been said, the chief factor is the efficiency of the labor employed. A study of the costs reported and the conditions surrounding each case shows conclusively that while local conditions may cause a variation of from 1 to 5 cents per thousand the excessive costs were in every case due to poor supervision, inefficient labor, or both; in short, to poor management. In any one of the cases mentioned had the other parts of the logging operation been as poorly managed the company would have gone bankrupt before the close of the season.

Based on all cases reported, the average cost of brush piling, according to Forest Service regulations, is 33 cents per thousand feet b. m., or $6.24 per acre, although the last figure means but little. This is extremely conservative, and with ordinary business management can be reached in any section of the State. Eliminating the cases where the costs are unreasonably excessive, the cost of piling averages but 24 cents per thousand feet b. m., which is a fair figure to apply under ordinary conditions.

BRUSH BURNING

Purpose of Burning

Since brush disposal in District 5, as has already been shown, is primarily a matter of protection, the chief reason for brush burning is obviously the same. Considerable argument has arisen, however, as to whether the increased protection due to burning offsets the danger involved, the unavoidable damage to reproduction and standing timber, and the additional expense. If due precautions are not taken and if the burning is not done carefully, it is extremely doubtful if brush burning is desirable, since proper piling overcomes the chief dangers resulting from logging operations, viz, the rapid spreading of fire through the slash and the difficulty of making fire lines. With due care and proper supervision, however, the greater portion of the brush on a given sale area can be burned at a nominal cost per thousand and the damage resulting will be negligible, while the degree of protection will undoubtedly be increased somewhat.

Dangers and Difficulties

As outlined above, the chief danger of brush burning is the chance that the fire will get beyond control. Where the stand is thick a certain amount of damage by scorching is usually unavoidable, although this can be greatly reduced by proper piling and careful burning. In the high fir belt previously mentioned, there is added the danger of a ground fire starting in the deep litter and buried half-rotten logs so common in this type. Such a fire resulted from brush burning on the Tahoe Forest in 1909 and burned until the heavy snows buried and extinguished it. Fortunately, however, the fire started late in the fall and the storms came early, so that only a small area was burned over. Under other circumstances a bad fire would have resulted.

The conditions which increase the dangers of brush burning also increase the difficulties by adding to the precautions necessary. Beyond a certain point, also, the difficulties increase as the fire danger decreases, owing to the more or less unfavorable weather conditions which usually prevail.

Time and Conditions for Brush Burning

The most satisfactory time of year for burning brush under ordinary conditions, experience has shown, is immediately after the first storms of the fall following the cutting. The brush by this time has usually be-

come thoroughly seasoned and burns readily. The piles dry off quickly after a storm and can usually be burned with little danger of the fire spreading, although a long dry spell following the fall rains may make it necessary to discontinue operations until the winter storms set in. Usually, however, the interval during which brush burning is possible this late in the season is too short to allow much to be accomplished.

Given good piling, dry piles, damp ground, and no wind, we have ideal conditions for brush burning. A thin blanket of snow or a moderate and steady breeze are also at times desirable. Hot, dry days, and days when strong or fitful winds prevail, are to be avoided; or, if burning must be done under such conditions, the starting of fresh fires should be confined to the late afternoon and evening.

The greatest objection to fall burning is that it is likely to be interrupted at any time by storms or shut down completely by heavy snow. Brush burning, however, at this time of year is much more satisfactory and justifies every effort to accomplish as much as possible at this season.

Next to fall, early spring is the best season for brush burning. Taken at the psychological time, when the snow has melted from the piles, but not from the ground surrounding, burning can be done very satisfactorily. At this time of year, too, the rising sap and the abundance of moisture in leaves and bark makes standing trees and reproduction much less liable to damage than at any other season. On the other hand, in spring the danger of fire increases constantly from day to day and storms cannot be depended on to take care of smoldering piles and buried logs. With the disappearance of the snow the ground dries out rapidly and the utmost vigilance is necessary to keep the fires under control, the worst feature being that they are liable to break out unexpectedly, and one can never be sure when the fires are out.

At best, the results of spring brush burning are never quite as satisfactory as fall. When burned while the snow is still on the ground, for instance, there almost invariably remains a circle of brush that was too wet to burn. Another drawback is the difficulty of firing the piles, which is often considerable, owing to the branches not being thoroughly dry. In such cases it is often necessary to carry dry brush some distance to start them, or to resort to the use of oil, all of which tends to increase the cost of the operation.

Methods and Equipment

Experience has shown that brush burning can be done to the best advantage by two men working together. One man should never attempt

this work alone, since there is always the danger of the fire escaping and getting beyond control before help arrives. Unfortunately this very thing has occurred in a number of instances. Two men, however, are generally all that are needed and can work to better advantage than a larger number, since there is a limit to the number of piles that can be set safely at one time in one vicinity. If more men are to be employed, they should work on different parts of the area. Even with two men it is often necessary, where the brush is thick, to light alternate piles, or even every third pile, going over the area two or three times in order to avoid creating too great a draft and starting a crown fire.

Numerous other expedients are frequently resorted to by the experienced brush burner, such as lighting a pile on the leeward side, so that in burning back against the wind it will be consumed slowly; lighting a pile at the top, so it will have to burn down for the same reason; banking a pile with dirt, snow, or wet brush on the side toward near-by reproduction to make it burn slowly and to hold in the heat; taking advantage of winds prevailing at different times of day to burn the brush in the lee of standing trees and reproduction; burning at night when the days are windy and the fire is apt to run, and many others.

Properly piled brush, unless water soaked, will burn up clean with little or no attention. Flat piles, however, require more or less "chucking up" to insure a clean burn, and irregular and open piles often require almost constant attention to secure satisfactory results.

While early in the fall or late in the spring the brush burns readily and the work proceeds most rapidly, it is attended with considerable danger, and constant vigilance is the price of safety. Later in the fall, when the heavy rains and early snows have reduced the fire danger to a minimum, or early in the spring, before the snow is all gone, there is less danger, but the difficulties of brush burning are greatly increased and the work at best proceeds slowly.

The equipment needed for brush burning consists of a shovel, a torch of some kind, a supply of coal-oil, and possibly an axe. The shovel is necessary in controlling the fires, for brush burning frequently resolves itself into fire fighting and one must always be prepared for such an emergency. The torch and coal-oil are useful at all times, but absolutely necessary when the brush is wet and catches fire reluctantly. At other times a shovelful of live coals or a burning branch will often serve, but great care is necessary in using them not to set a fire where one is not wanted; a good torch is always to be preferred.

Various and sundry torches have been used on the different Forests and a number of them have been found satisfactory. The brush-burning

torches furnished by the Service a few years ago were never very satisfactory, being clumsy, cheaply constructed, and using an inordinate amount of wick and oil. The regulation railway torch of copper and brass, with a riveted handle, has proved to be the most useful of this type of torch.

On the Tahoe a torch constructed of a piece of hoop iron about 3 feet long, wrapped at one end with sacking and with 6 inches of the iron bent back and clinched to hold it in place, proved most satisfactory. On the Stanislaus a similar torch was constructed by doubling a 6-foot piece of No. 9 telephone wire and twisting a roll of burlap or asbestos into one end. These torches were used by soaking them with coal-oil. The asbestos was found to last from two to six days if wound with fine wire to protect it from being torn to pieces when thrust into the piles. When burlap was used it was found necessary to renew it about twice a day. These torches consumed from one to two gallons per day, depending upon the condition of the piles and the readiness with which they ignited. Saw oil, costing 20 cents a gallon, was used for this purpose. In another instance strips of incense cedar bark 4 feet long and 1 to 2 inches in size were used with very satisfactory results, the bark absorbing the oil readily and making a light, efficient, and very cheap torch.

The advantage of the latter type of torch over the regulation wick variety is that it makes a large flame which will not blow out and which gives less trouble in igniting the piles. It must be used with care, however, and has the disadvantage of requiring an open can of oil to be kept handy.

Labor and Supervision

Brush burning is a much more particular and dangerous operation than piling and requires proportionately greater care and judgment. Thus the employment of a more responsible class of labor and more careful supervision is necessary. In the past brush burning has been done almost entirely by forest officers, although in some cases the operators have coöperated to the extent of furnishing a portion of the labor.

As has been said, two men make the ideal crew for this work, although where the fire danger is not great a larger number can be used to advantage. In any case only reliable and responsible men should be employed and, if possible, an experienced man should be in charge. As the men work alone to a large extent, however, the satisfactoriness of the results depends primarily on the care and judgment used by the men individually.

While energetic work, combined with good judgment, will decrease the

cost of brush burning, hurried and careless work and a slighting of the precautions does not pay. This has been shown in too many cases where the fire has got out and considerable damage has been done.

As to whether the work should be done by the operator, or wholly or in part by forest officers, there is little question. At best, the average operator considers brush disposal an added and more or less unnecessary expense and takes little interest in it aside from getting it done as quickly and cheaply as possible. With no future interest in the standing timber and reproduction, it receives little consideration at his hands, and anything less than a general conflagration is considered immaterial. On the other hand, a forest officer knows it is to his interest and to the interest of the Service to see that the work results in as little damage as possible and, at the same time, is efficiently done. It is practically necessary, therefore, that this part of brush disposal be handled under the supervision at least of competent forest officers.

Costs

The costs of brush burning, as reported, range from .003 to 22 cents per thousand feet b. m. and from 21 cents to $1.24 per acre. As in brush piling, however, the cost per acre has little significance. Taking all cases reported into consideration, the average cost of brush burning for District 5 is found to be $0.0465 per thousand, or $0.492 per acre. Eliminating the excessive costs which on analysis were found to be due to the small size of the sales involved, the average cost figures out to be $0.037 per thousand feet b. m., which is a conservative figure to apply in any case where brush burning is done under conditions at all favorable. This is evident when it is considered that the above is the average cost of burning under all conditions—good, bad, and indifferent.

The cost of brush burning is affected primarily by the readiness with which the piles burn and the amount of attention they require. These factors in turn, while dependent to a large extent on the manner of piling, are equally affected by the conditions prevailing at the time of burning. It is therefore evident that if brush is to be burned economically advantage must be taken of the times and seasons most favorable for it.

PRACTICAL CONSIDERATION OF BRUSH DISPOSAL AS A PROTECTIVE MEASURE

The statement has often been made that private owners would find it to their advantage to pile and burn the brush resulting from their logging operations as a matter of protection. Whether or not this is true depends

primarily on the value of the property to be protected and the relative cost and value of other means of protection. The need for protection of some sort is assumed for the purpose of this discussion, since the arguments for and against it are too numerous to enter into here.

A private operator considering this method of brush disposal as a protective measure first asks how much will it cost or what investment will be required. Next, whether or not the value of the property involved justifies the expenditure.

From the costs already given it will be seen that 25 cents per thousand feet b. m. for piling and 5 cents for burning is a fair estimate, although it is probable that burning would cost less, since reproduction is not usually considered by the private owner. Placing the cost of brush disposal at 30 cents per thousand, however, the actual investment would in ordinary cases approximate $4.50 per acre, since in California the average acre will cut about 15,000 feet b. m. If the stand was heavier the cost would be proportionately higher. What this would amount to by the time of a second cut at compound interest is shown in the following table:

Rate of interest.	Total cost per acre at time of second cut in—			
	20 years.	30 years.	40 years.	50 years.
3 per cent..............	$8.13	$10.92	$14.68	$19.63
4 per cent..............	9.86	14.60	21.60	31.98
5 per cent..............	11.94	19.45	31.68	51.60

It must be remembered, however, that the protection offered by brush piling and burning decreases rapidly after the first two years and may be said to be practically zero at the end of five years, owing to the natural accumulation of litter and the fact that in that time the brush, if left on the ground, would have largely decomposed. The money value, then, of piling and burning from a protection standpoint is limited to the money value of five years of protection—a figure that can only be determined by a comparison of the cost of protection for that period by various methods.

Experience has also shown that even during the five-year period brush disposal is no protection against crown fires or to any great extent against serious fires starting on land adjoining. On the other hand, brush disposal most certainly greatly reduces the danger of fires starting on the area itself.

Experience has shown that efficient fire patrol can be maintained at an annual cost of 3 cents* or less per acre. What the cost of this method of protection would amount to at this figure by the time of a second cut is shown in the following table:

Rate of interest.	Total cost per acre at the time of a second cut in—			
	20 years.	30 years.	40 years.	50 years.
3 per cent..............	$0.81	$1.43	$2.26	$3.38
4 per cent..............	.89	1.68	2.85	4.58
5 per cent..............	.99	1.99	3.62	6.28

In other words, for the initial cost of piling and burning brush on the average acre (or $4.50) it could be patrolled for approximately 58 years, allowing 3 per cent on the actual investment, or 53 years beyond the time which piling and burning offers any protection. At the same time a saving of the interest which would have accumulated at 3 per cent if the money had been invested in piling and burning would be effected, amounting to $24.99 per acre—not an inconsiderable sum.

While from the standpoint of public ownership interest may be left out of consideration, from the standpoint of the private owner it is a vital consideration and net returns must at least equal the returns at ordinary interest to make a proposition attractive.

While it is evident, therefore, that piling and burning is a relatively expensive method of protection, there are other facts to be taken into consideration. For instance, if the danger of fire is great and confined chiefly to the area itself, it would probably be advisable to reduce the fire risk to a minimum by piling and burning.

If, on the other hand, the danger of fire is chiefly from adjoining land, fire lines and efficient patrol would undoubtedly be more economical and, in most cases, equally effective.

* Cost of fire fighting and patrol for the fiscal year of 1912 amounted to ¾ cent per acre.

Cost of protection for 1912 reported by the Western Forestry and Conservation Association as 1 cent per acre for the total area protected, or 2 cents per acre based on the acreage owned by members of the association.

Fire protection on the lands of the Crown Columbia Paper Company cost that company 2.2 cents per acre. This figure, based on an average of three years, includes the total annual cost of patrol and maintenance and one-tenth of the investment in permanent improvements.

The value of the property involved has also been mentioned as an important factor and it is, although largely a psychological one, since beyond the point when cost of protection reduces the future profits on the investment below that to be obtained at prevailing interest rates, the amount to be paid out for protection depends on the chance the investor himself is willing to take on the loss of remaining interest or capital.

Where land is retained after cutting for timber production alone, the protection charges justified should theoretically be based on the investment represented by the merchantable timber left standing and the expectation value of both timber and reproduction. The small stand left for a second cut on most private operations, however, and the correspondingly small yield to be expected will not ordinarily justify in the mind of the private operator any great outlay for protection. Until the time comes, then, when operators handle their lands with the idea of a sustained yield, or at least a second cut within a reasonable time, it is doubtful if the matter of protection for cut-over lands will receive very serious consideration. In any event it is certain that the method involving the smallest cash investment will be looked on most favorably.

COMBATING THE LARVÆ OF THE JUNE-BUG IN FOREST NURSERIES

BY PROFESSOR DECOPPET, SWISS EXPERIMENT STATION

TRANSLATED BY G. A. PEARSON AND A. J. JAENICKE

Contributed

The Schweizerische Zeitschrift fur Forstwesen for April, 1912, describes the experiments of Professor Decoppet in combating the May-beetle in forest nurseries at the Swiss experiment station. A similar insect injury, which has been ascribed to the common June-bug or May-beetle, has been experienced at the Fort Valley Experiment Station during the past two years. Since this trouble undoubtedly occurs in other sections of the country, the German article has been translated in order that the information may become available to the Forest Service.

The injury consists in the destruction of the roots of seedlings and transplants. At the Fort Valley Experiment Station western yellow pine has been attacked both in the nursery and in the field. In some instances the damage is confined to cutting off the laterals, but many instances have been observed where the entire root, up to one or two inches below the root collar, has been devoured. The presence of the larvæ is first manifested by the drying up of the needles; and when the injury has advanced to this stage, the plant can readily be pulled out of the ground. The injury was first experienced in the summer of 1911, when a considerable amount of field planting was done in spots about two feet in diameter spaded up the preceding fall. As is shown by Decoppet's experiments, this is just the soil condition favoring the deposition of eggs by the adult beetle. Comparatively little damage was experienced in the field planting of 1912, when but few prepared spots were used. Curiously enough, no damage was observed in the nursery during 1911, but in 1912 the damage was really serious. The work occurred in patches two or three feet in diameter; but it was quite evident that the larvæ followed the rows, since frequently every transplant in a row half way across the bed was killed. It is estimated that from 5 to 15 per cent of the transplants were killed by this cause. However, the damage is not confined to the plants which are killed outright. Investigations have shown that many transplants, which are apparently uninjured, have their laterals cut off to such an extent as to render them unfit for field planting. Second-year seedlings were also attacked, though in a lesser degree than the transplants.

The larva has not been positively identified, but several entomologists have expressed the opinion that it is the larva of the common June-beetle. It is a white grub about 3/4 inch in length and 1/4 inch in diameter. Only a few specimens have been found, and therefore it appears

that each individual is responsible for a large amount of damage. One specimen was placed in a can of earth containing an uninjured western yellow-pine transplant of good root development. After two weeks about one-half of the roots had been destroyed.

It is purposed to try the carbon-bisulphid treatment prescribed by Professor Decoppet at the Fort Valley Experiment Station this year. The apparatus used at the Swiss experiment station will not be purchased until its need and applicability under our conditions is demonstrated. Since only a few beds will be treated this year, it is believed that the carbon bisulphid can be applied satisfactorily by pouring measured quantities into holes made with a tube used for soil sampling. The results of the experiment will appear in the 1913 report of this station.—G. A. PEARSON and A. J. JAENICKE.

For several years the study of the biology of the May-beetle and its extermination in the forest nursery has been on the program of the forest experiment station at Zurich. This investigation was assigned to Professor Decoppet, who since 1904 has carried on experiments related to this subject in the forest nursery of the Canton Waadt at Farzin, which, after their completion, are to be published in the experiment station record and compared with the results obtained in Canton Zurich.

The Farzin nursery lies 780-800 meters above sealevel, three kilometers north of the railroad station Romont, and slopes slightly to the northeast. The deep, fertile, marly soil is underlaid by clay. The present seed-beds, together with the abandoned and now reforested seed-beds, contain more than two hectares, and are 300-900 meters distant from the nearest fields. The May-beetle is very abundant in the region. The flight-years,* 1906, 1909, 1912, etc., prevail here. Formerly nurseries did not suffer much from the beetle. However, in 1904, two-thirds of the area showed severe injury. Two hundred thousand two-year-old transplanted red fir, valued at $500, were destroyed. This gave rise to the investigations about to be described.

A. TREATMENT WITH CARBON BISULPHID.

Carbon bisulphid is a transparent, easily inflammable liquid, which volatilizes rapidly. The vapor kills insects which breathe it. Especially in light soils, a small dose is sufficient to destroy all insects. It is best if the carbon bisulphid is distributed evenly through the region of the plant roots and is introduced into the soil at numerous points, since one thus gets along with the least possible quantity and there is less danger that the material will injure the plant.

* Years in which the larvæ become adults.

In applying the remedy, an instrument with which to bore holes and squirt the carbon bisulphid into the ground is used. A steel tube, which one can force 10 to 12 inches into the ground by means of two horizontal handles and a pedal, surrounds the container of the liquid. A small pump sucks this up and forces the liquid out into the soil near the tip of the tube. The piston-rod of the pump ends above in a wide head, which one seizes when setting it (the piston-rod) in motion. The length of the piston-rod gauges the quantity of the liquid forced in. If it is pushed in entirely, it contains 10 grams. If one wishes to use less, one or several bronze rings are inserted beneath the head (which can be unscrewed) of the piston-rod. It is advisable to inject the individual doses in numerous holes scattered over the area, rather than to make but one injection, because results are much more satisfactory. A liter of the liquid weighs 1,263 grams—thus a very heavy liquid. Accordingly, one should be careful not to inject it into the ground too deeply. Again, if not placed deep enough, it will evaporate at the surface of the ground. It is of advantage if the ground has become porous, dry, and warm, as results from the spring sun, which at the same time starts the activity of the May-beetle larvæ anew.

Light soils require but little of the liquid, while heavy soils need a great deal. Too much injures the plants; too little does ineffective work. Trial will determine the proper amount.

1. *Experiments of 1904.*

The treated beds contained two-year-old transplanted pines. The larvæ were numerous, originating from the flight-year 1903, and had already begun their feeding in the fall of this year and continued it in the spring of 1904. The application of carbon bisulphid was made on the 29th and 30th of July. Many roots were entirely eaten off. Some of the plants, which looked well above ground, had their roots gnawed beyond recovery.

Each injection opening received 3-6 grams. The beds were then left to themselves, and, at the end of the experimental period, the plants were taken out and counted. The beds were isolated by ditches 40 centimeters deep. One of the beds was treated again on May 3, 1905.

Results:

a. The 25-gram dose per square meter gave practically no results—viz., a loss of 75 per cent as compared with a loss of 88 per cent in the untreated bed.

b. 40-50 grams works well, and showed a loss of only 18-19 per cent.

c. Where the treatment was repeated in 1905 the loss was only 1 per cent.

2. *Experiments of 1905.*

In the past year the two extremes—that of too much and too little—were not definitely determined. Besides, the experimental areas were somewhat small. For this reason pines which were two years old when transplanted in 1904 were treated. The larvæ had been present two years, had wintered at a depth of 30-35 centimeters, and had begun their feeding at a depth of 10-15 centimeters.

Results:

a. The untreated beds used for comparison showed losses ranging from 55 to 88 per cent, and an average of 69 per cent.

b. 45 grams showed a loss of 23-50 per cent, with 38 per cent as the average.

c. Larger doses give greater losses, viz:

	Per cent
72– 96 grams	44–55
120–150 grams	50–67
250 grams	91

d. The losses in the treated beds vary greatly, as do also the losses in the untreated beds.

Doses that are too strong kill both larvæ and plants, the latter becoming red a few days after the injection. The following doses killed plants, as shown:

	Per cent
120–150 grams per square meter	26–42
250 grams per square meter	74

Less than 45 grams injected at 15-20 places did not kill any plants. With stronger doses the larvæ gnawed only 18-30 per cent, or an average of 25 per cent of the plants.

What doses are necessary to kill a part or all of the larvæ? To this question the 1905 experiments answer:

a. 45-60 grams per square meter killed only 12-15 per cent of the larvæ present.

b. 150-300 grams killed 60-95 per cent of the larvæ, but also injured the transplants.

c. It is well to make the points of injection numerous, and to inject a little at each point.

3. *Experiments of 1906.*

We ask whether the treatment has preventive efficacy, and whether it prevents the May-beetles from laying their eggs in the experimental beds in flight-years. Untreated beds were alternated with treated beds, and separated by ditches 40 centimeters deep. A dose of 50 grams per square meter, much divided, was used. The majority of the beds contained two-year-old recently transplanted fir, but there was one bed each of similarly treated Weymouth pine and Douglas fir.

Results:

a. No preventive effect resulted. The experimental beds showed a loss of 7.8 per cent, while the untreated beds showed an almost equal loss of 8.7 per cent.

b. Both rows, treated and untreated, show large variations in loss from bed to bed. The larvæ attack the fine roots in their first year (fall).

4. *Experiments of 1907.*

These experiments are comparable to those of 1904, because one-year-old larvæ had to be contended with. This time, however, operations were begun earlier in the year, and partially on beds which had previously undergone treatment. Never more than 50 grams per square meter, distributed among 10-17 holes, was used. Three beds of three-year-old transplanted red fir, three beds of similar Weymouth pine, and one bed of Douglas fir were used.

Results:

a. Loss in the treated beds, 6.4 per cent.

b. Loss in the untreated beds, 20.1 per cent.

c. The loss from bed to bed varies greatly.

d. The loss is considerable in the Weymouth pine and the Douglas fir.

What causes this striking difference between beds? To this, with the experiments as the basis, we can answer as follows: Wherever injections were made for preventive purposes in 1906 and 1907, the damage was quite small. The preventive treatment the previous year was just as effective as the injections made against the larvæ now present.

5. *Experiments of 1909–1911.*

The year 1909 was another flight-year. The preventive treatment and the efficacy of the remedy in the transplant beds were tested out.

A few of the experimental beds received injections on the 28th and 29th of July; others were treated a second time on the 25th and 26th of

August, all in 1909. The quantity used was 45 grams per square meter, distributed among nine openings.

Red fir, which had been transplanted in 1909, was treated. These beds were observed till 1911, and in that year the injury from May-beetle larvæ was ascertained.

Results:

a. One treatment gave a loss of 0.6 per cent.
b. Two injections gave a loss of 0.7 per cent.
c. No injections resulted in a loss of 8.7 per cent.

The conclusions drawn from the use of carbon bisulphid follow later on in the article.

Cost of the Treatment.

A dose of 40 grams per square meter costs 4-5 rappen for the area named. The increase in cost is 2.5 francs (48 cents), an increase of about 10 per cent.

B. PREVENTION OF THE EGG-DEPOSITION OF THE MAY-BEETLE

The female beetle likes to lay its eggs on open, sunny, light and dry soil which is without covering. Cannot the soil be artificially protected against the laying of eggs? To determine this, experiments were carried on in the nursery at Farzin.

a. Observations in the Nursery.

The behavior of the beetle at the time of egg-deposition makes the establishment of nurseries in the proximity of fields and in windy places inadvisable. It is better to establish them in small openings within the forest. The appended figure shows the nursery at Farzin at the beginning of the experiment. A row of beds established at the edge of the stand showed the following losses:

	Per cent
Bed A	Loss, 54
Bed B	Loss, 57
Bed C	Loss, 64
Bed D	Loss, 87
Bed E	Loss, 87

Forest	A	B	C	D	E

The loss increases with the distance from the shade of the old stand. *Egg-deposition is hindered by the surrounding with old stands.* This was determined at Farzin, where two small nurseries situated within a stand remained untouched in spite of the proximity of large fields.

Damage from the larvæ is noticeable at first in individual spots, which, separated at first, begin to grow at the periphery until they finally touch each other. This feeding in spots by the larvæ is perhaps due to the fact that the beetle lays its eggs in groups of 10-25, each female laying two or three clusters.

The place of deposition is the starting point of the damaging colony. Most of the colonies at Farzin arose where the trees of the original forest had stood, which can be partially explained by the fact that at these very spots the soil, by clearing off the trees, was loosened the deepest; and, again, it may be traced to the subsequent loss of soil fertility.

b. Measures for Prevention of Egg-deposition.

Such precautionary measures should either be the distribution of strong-smelling, offensive substances or the hardening of the soil surface. A powder of this character, from the Beck factory at Pieterlin (Bern), was recommended by Oberfoerster Cunier, of Aarberg. It smells very much like tar, and keeps the beetles away if used at the rate of 300-500 grams per square meter. Our experiments show five to six times more larvæ in untreated than in treated beds.

Similar experiments in the forest nursery at Naegelsee (Winterthur) showed no larvæ in beds on which the material had been scattered, and an average of 40 larvæ for untreated beds.

Other experiments of like character gave no conclusive results.

The soil in two instances was covered with leaves and brush, with good results in one case and no effect in the other.

The treatment with the powder costs 0.8-1.0 rappen per square meter.

C. GENERAL CONCLUSIONS FROM THE EXPERIENCE WITH CARBON BISULPHID

Carbon bisulphid certainly works well. At the last, when we used 40-50 grams per square meter, distributed among six openings, we had a loss of only ½ per cent of the plants. At the start, due to improper procedure, a loss of 20 per cent for treated beds and 80 per cent for untreated beds resulted. In the untreated beds the loss fell for the years 1904-1911 in a very remarkable manner from 80 per cent to 9

per cent. How is this to be accounted for? Apparently the substance not only results in the death of the insects, but slowly and surely improves the soil. In the course of the years of experimentation the material sooner or later becomes available in all parts of the area.

Girard, of France, and Oberlin, of Alsace, have pointed out that carbon bisulphid makes the soil more fertile; delays the loss of soil fertility; that it is not only an insect destroyer, but also a factor in soil improvement. By this means Oberlin increased the bean yield of a garden from 85 to 125 kilograms. Upon what does this action depend? The answer is not simple. Professor Henry, of Nancy, has begun investigations regarding it, and found that the Robinia produced three times as much organic material where it was used as without it, and that this increased growth appeared in the branches and not in the foliage. Henry considers carbon bisulphid very valuable to increase the fertility of seed-beds, and in afforestation in mountainous districts to bring about a rapid strengthening of the transplants.

Our experience confirms this. The untreated spruce have hardly grown, while the treated plants grew vigorously.

We draw the following conclusions:

1. Carbon bisulphid increases the fertility of the nursery and partially kills the insects, resulting in a lessening of the gnawing by the larvæ. Both work together and make the plants more resistant.

2. The material works best in doses of 40-50 grams per square meter, distributed and injected in 6-8 openings. Freshly plowed soil should not be treated; neither should soil be cultivated immediately after the treatment. Soil that is too dry or too wet is not suited for the treatment. Injections should not be made deeper than 15 centimeters.

It would be interesting to carry on new experiments with the treatment in places where carbon bisulphid has not been applied up to this time. These will be carried on at Farzin. The forest experiment station would like to begin investigations within the sphere of the Bern flight-years (1909, 1912, etc.), if the property-owners concerned would offer the opportunity.

ZURICH, *February,* 1912.

SOME FINANCIAL FOREST PROBLEMS

BY W. B. BARROWS

Contributed

I

FINDING THE FOREST PER CENT *

The crucial question, upon the answer to which depends the application of private forestry is, "What rate of interest shall I receive if I invest my money in the growing of timber?" And this question must be answered by the forester who attempts to show that it will pay to grow a species for lumber and other forest products.

Any one who has worked out problems of this kind, especially if he has not had the advantage of using a calculating machine of some kind, will admit that a great deal of arithmetic must be gone through to arrive at final results. These results, too, are often stated in an unsatisfactory way. For example, it has been stated that white pine on a 60-year rotation will return 4 per cent and $216.32, or 5 per cent and $90.17, or 6 per cent and —$114.30, the additional sums being termed "net profits"†. Since the calculations at 5 per cent show a positive net profit and those at 6 per cent a negative one, it follows that somewhere between 5 per cent and 6 per cent there is a rate of interest, the forest per cent, which if used in the calculations would show a net profit of zero. This forest per cent then would be the actual rate of interest received by the investor on the capital invested. If it could be determined that in this case the forest per cent is 5.5 for a 60-year, 6.3 for a 55-year, and 7.0 for a 50-year rotation, would it not be much simpler to state the facts in this way than to bring in various "net profits" at various per cents at each rotation? It is the object of this paper to explain a short method of determining the forest per cent and thus make possible a clear, concise statement in regard to the returns to be expected. Incidentally it may be added that "net profit" is a very

* "The rate of interest yielded by the capital invested in forestry, (is) here called the 'forest per cent.'" Schlich's Manual of Forestry, vol. III, chap. VI.

† "Handbook on Forest Mensuration of the White Pine in Massachusetts", by Harold O. Cook, under the direction of F. W. Rane, State Forester, State House, Boston, Mass.

unfortunate term to use in this connection. What is called a net profit here is only part of the net profit, and might better be called a premium. The term "premium" will therefore be used. The net profit in any transaction is the difference between the gross receipts and the gross expenditures. If I invest \$100 and at the end of a year receive \$105 I have made a net profit of \$5, or 5 per cent. If I expect to receive \$105 and instead receive \$107, the additional \$2 is not net profit, but corresponds to the premium mentioned above. The real net profit is \$7. If I receive only \$100.01 at the end of a year, there is still a net profit of one cent. The confusion in the case of forest calculations is caused by the fact that in order to find the cost of a forest at the end of the rotation it is necessary to assume a rate per cent with which to calculate that part of the cost represented by annual expenses. If the actual cost without interest—that is, the sum of all disbursements—is less than the selling price at the end of the rotation, there will be a net profit. The determination of the forest per cent from these figures is an entirely different matter.

Take another example—cottonwood along the Mississippi with a 35-year rotation. Assuming certain costs of land, planting, and so on, the premiums are as follows:

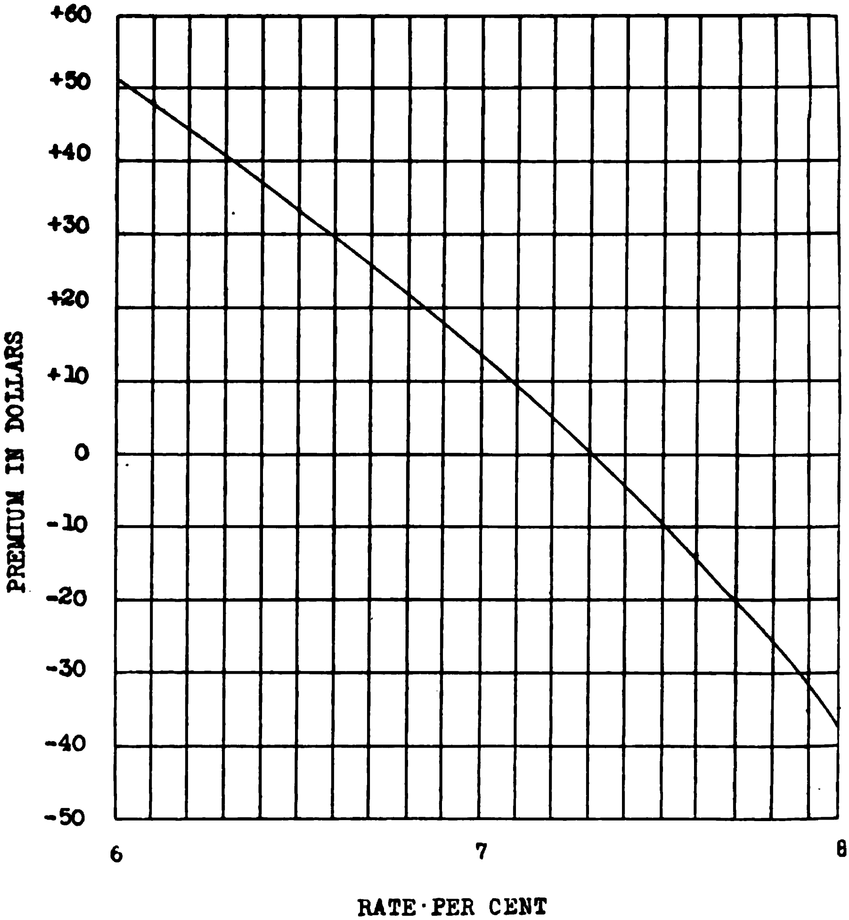
With interest at 6 per cent the premium is + \$51.50
With interest at 7 per cent the premium is + 13.57
With interest at 8 per cent the premium is — 37.81

Plotting these values and drawing a curve through them, we get the result shown on page 364.

Examining this curve, it will be seen that as the rate per cent increases the premium decreases. At about 7.3 per cent it crosses the zero line, and from that point on the premium is a minus quantity. In other words, the investment yields 7.3 per cent. To check this result all the costs were recalculated, using 7.3 per cent compound interest, and the result was a premium of \$0.13.

This method gives results which will, I believe, always be accurate to the nearest tenth of a per cent, and this is close enough for all practical purposes.

To sum up, then, the use of this method makes it possible to determine the forest per cent to the nearest tenth of a per cent with practically no more expenditure of time than is required to determine it to the nearest per cent, and it at the same time eliminates the need of bringing in the confusing premium or "net profit."



II

CAPITAL IN FORESTRY

It will be noticed that the ordinary method of calculation assumes that when thinnings are not considered the capital invested consists of the sum of the value of the land, the cost of formation, and the annual expenses discounted to the beginning of the rotation. This is open to the objection, pointed out by W. D. Sterrett, that it is preferable not to capitalize the annual expenses of growing timber, and that taxes and expenses of protection and administration should be paid out of gross receipts, just as the coal bills of a railroad are. It is true that the re-

turns of any particular planted acre are not realized for a considerable period, but this state of affairs is not found under forest management. It should be assumed that in a forest there are enough stands so that all age classes are represented. Equal annual returns naturally follow. With a yearly income the annual expenses will of course be paid out of the gross yearly receipts. Why, then, should the capital be watered enough to pay operating expenses for the whole rotation?

The amount of the actual capital invested is measured by the money required to pay for the land and the formation of the stand. Comparing a forest with a factory, the land with its trees corresponds to the land and the factory buildings and machinery; the taxes and expenses of protection and administration correspond to the taxes, the wages of employees, the cost of fuel and other supplies, and similar expenses; the amount charged off against the cost of formation corresponds to the money applied to the sinking fund to replace the buildings and machinery.

If, then, the capital is represented by the cost of the land and that of formation, how shall the forest per cent be determined? If a capital of \$1 becomes at the end of 20 years \$3.21, it follows that the interest rate was 6 per cent compounded annually. This is obtained by using the formula $p = 100\left[\sqrt[n]{\frac{C+c}{C}} - 1\right]$, in which $p =$ the rate per cent, $C =$ the original capital, $c =$ the net profit at the end of the period, and $n =$ the number of years in the period.

In the case of the forest, let

$S =$ the value of the stumpage per acre.
$L =$ the value of the land per acre.
$F =$ the cost of formation per acre.
$A =$ the annually recurring expenses, with interest at, say 6 per cent, carried through to the end of the rotation.
$n =$ the number of years in the rotation.
$p =$ the rate per cent.

Then, in the formula above, $C = L + F$

$$c = S - F - A$$

or, substituting $p = 100\left[\sqrt[n]{\frac{S+L-A}{L+F}} - 1\right]$

PROCEEDINGS OF THE SOCIETY OF AMERICAN FORESTERS

Copies of the Proceedings may be obtained from the Secretary for 50 cents each number.

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NUMBER 2.—William F. Hubbard, Obituary.—*F. H. Newell*, The Reclamation Law and Its Relation to Forestry.—*Edward T. Allen*, The Application and Possibilities of the Federal Forest Reserve Policy.—*George W. Woodruff*, The Disposal of Public Lands.—*Alfred Gaskill*, Silviculture Applied to Virgin Forest Conditions.—*Albert F. Potter*, Objections to the Forest Reserves in Northern California.—*George L. Clothier*, The Great Kansas River Flood of 1903.—*J. B. Lippincott*, The Necessity for Saving the Forests on the Watershed of the Sacramento River.—*W. J. Gardner*, Results of a Rocky Mountain Forest Fire Studied Fifty Years after its Occurrence.

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